

APRIL 1957

35 CENTS

POPULAR MECHANICS MAGAZINE

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A PM Round Table Conference Looks at
THE ATOMIC AIRPLANE
—page 100



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**WHAT OWNERS SAY
ABOUT '57 CHEVROLET**

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**WHAT OWNERS SAY
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A Round Table Conference Looks at THE ATOMIC AIRPLANE

Taking part on this panel are three of our country's leading experts in the fields of nuclear physics and aircraft design:

Dr. Lyle B. Borst, chairman of the physics department, New York University; Mr. Frederick K. Teichmann, assistant dean of NYU's College of Engineering; and Mr. Lee A. Ohlinger, radiation expert and head of the computer center, Northrop Aircraft, Inc.

QUESTION: Recently we've been hearing about nuclear-powered planes that will fly 80 times around the world without refueling, carry hordes of passengers to remote places at supersonic speeds, pull trains of gliders all over the skies. In your opinion, will the atom plane be capable of these things?

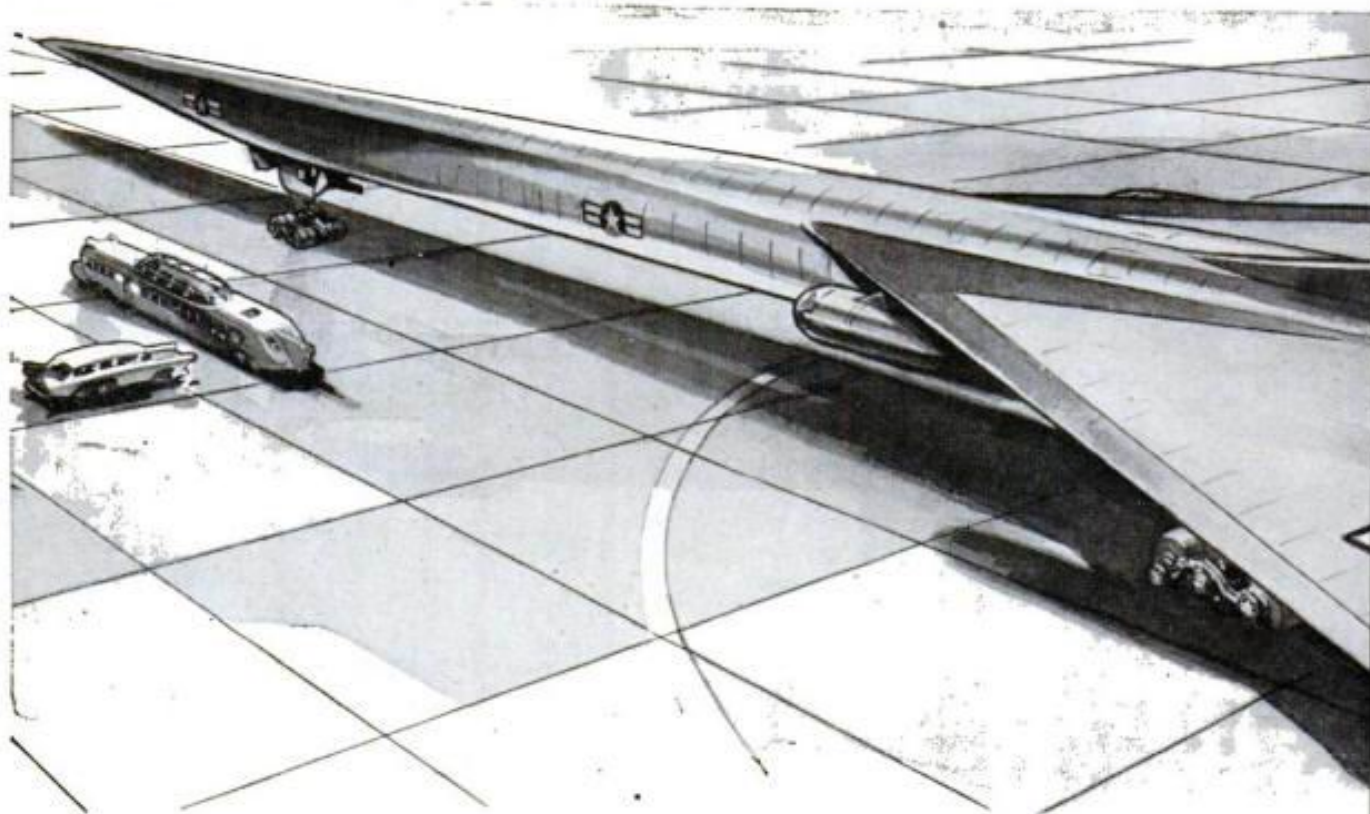
Dr. Borst: Some recent guesses are plausible, but they'll hardly be combined in one package. Certainly not in the first nuclear aircraft. The first problem will be to get one off the ground.

Question: What is your best estimate of when we'll see A-planes flying?

Dr. Borst: Ten years is a realistic estimate of the time it might take to put the first atom-powered plane in the air. That plane probably will be a long-range bomber. At best, it may be the prototype for a cargo ship that could ferry supplies to some far-off, roomy place, like Antarctica. But it will be a long time—maybe 20 years after that, as a grab-bag guess—before any kind of commercial nuclear aircraft will be economical and safe enough to fly passengers.

Mr. Ohlinger: I would estimate from 3 to 10 years for the first atomic plane. Technically, it should be possible to build a

Artist's conception of a delta-wing atomic plane places two reactors near center and crew atop tailfin



safe nuclear-powered commercial plane in 10 years, if the economics were favorable.

Question: Can you give us a general description of what the first nuclear-powered plane might look like?

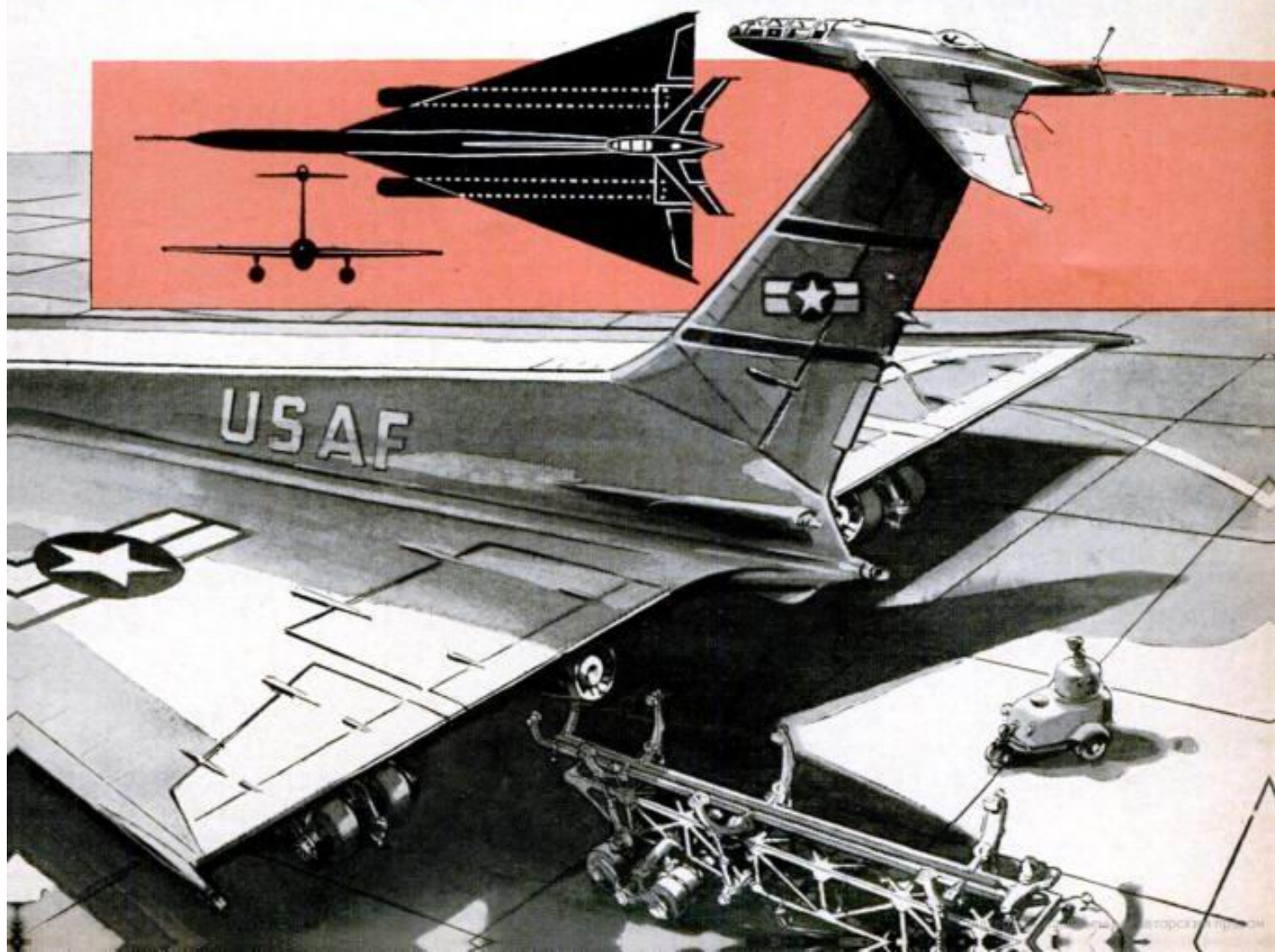
Mr. Ohlinger: From outside, it probably will not look vastly different from a conventional plane. The most desirable place for the crew is in the nose and, since the crew should be as far away from the reactor as possible, the nose may be exceptionally long. It can be offset by "heavying up" the shielding. The reactor and shielding will be heavy enough to bring the plane into the 250,000 to 500,000-pound gross-weight class. So, the size of a normal fuselage (such as in the XB36H, where the fuselage is around 13 feet in diameter) will be plenty large enough to hide the reactor and shielding without special bulges.

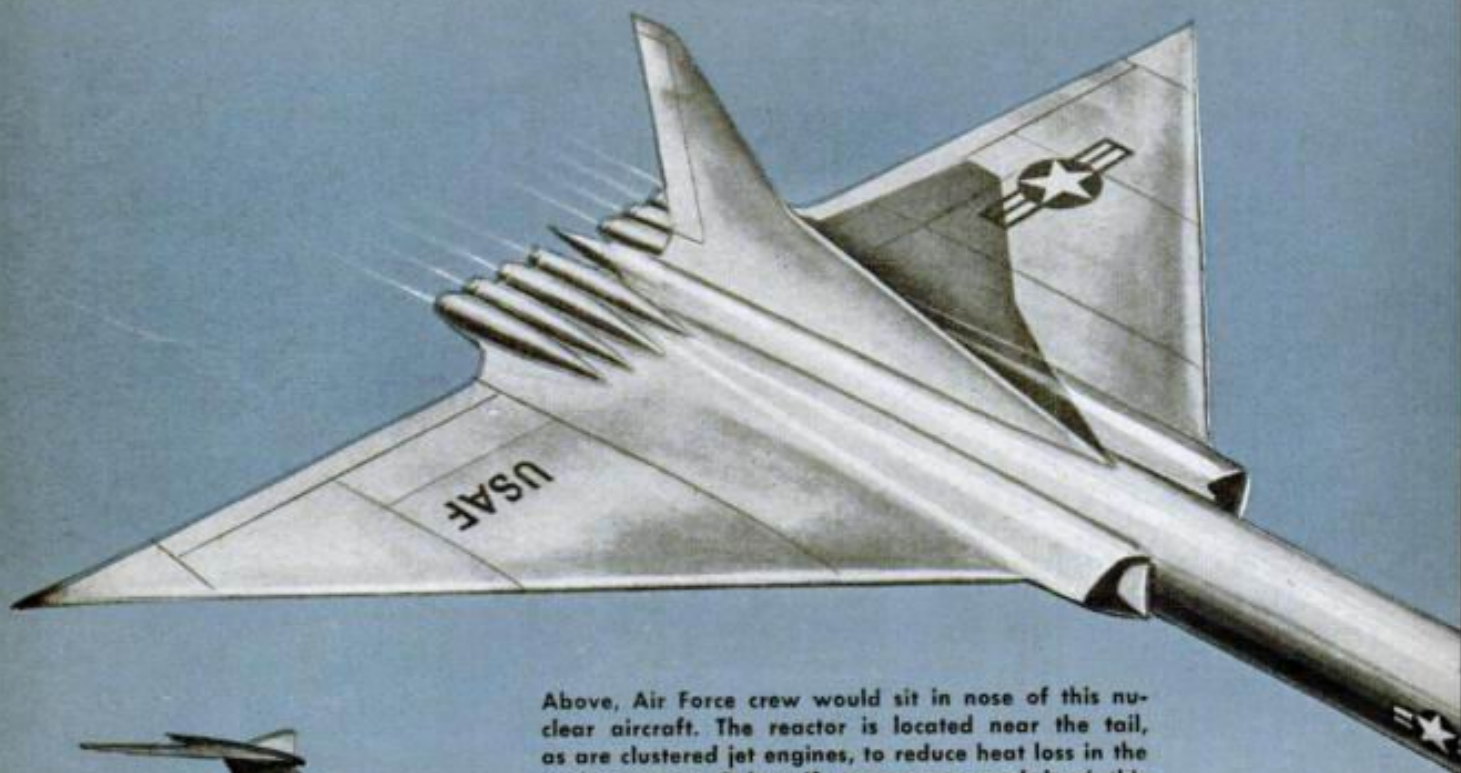
Hot gases from the reactor to the jet engines must pass through ducts where heat loss can occur, so it will be desirable to keep the power plants close to the reactor. Therefore, all of the power plants will be clustered close to the fuselage and not out on wing pods.

Finally, if we are to take advantage of the unusual "endurance" and high-speed characteristics of the nuclear-powered plane, we can expect the same problems we face in high-speed combustion-powered



Above, F. K. Teichmann's work includes research on landing gear, high-lift devices and hulls. Below, Dr. Lyle B. Borst adjusts his "pickle-barrel reactor"





Above, Air Force crew would sit in nose of this nuclear aircraft. The reactor is located near the tail, as are clustered jet engines, to reduce heat loss in the nuclear system. Below, if necessary to crash land, this flying boat could "bury" radiation hazard in water



planes—aerodynamic heating and protection of such vulnerable parts as, for example, the windshield.

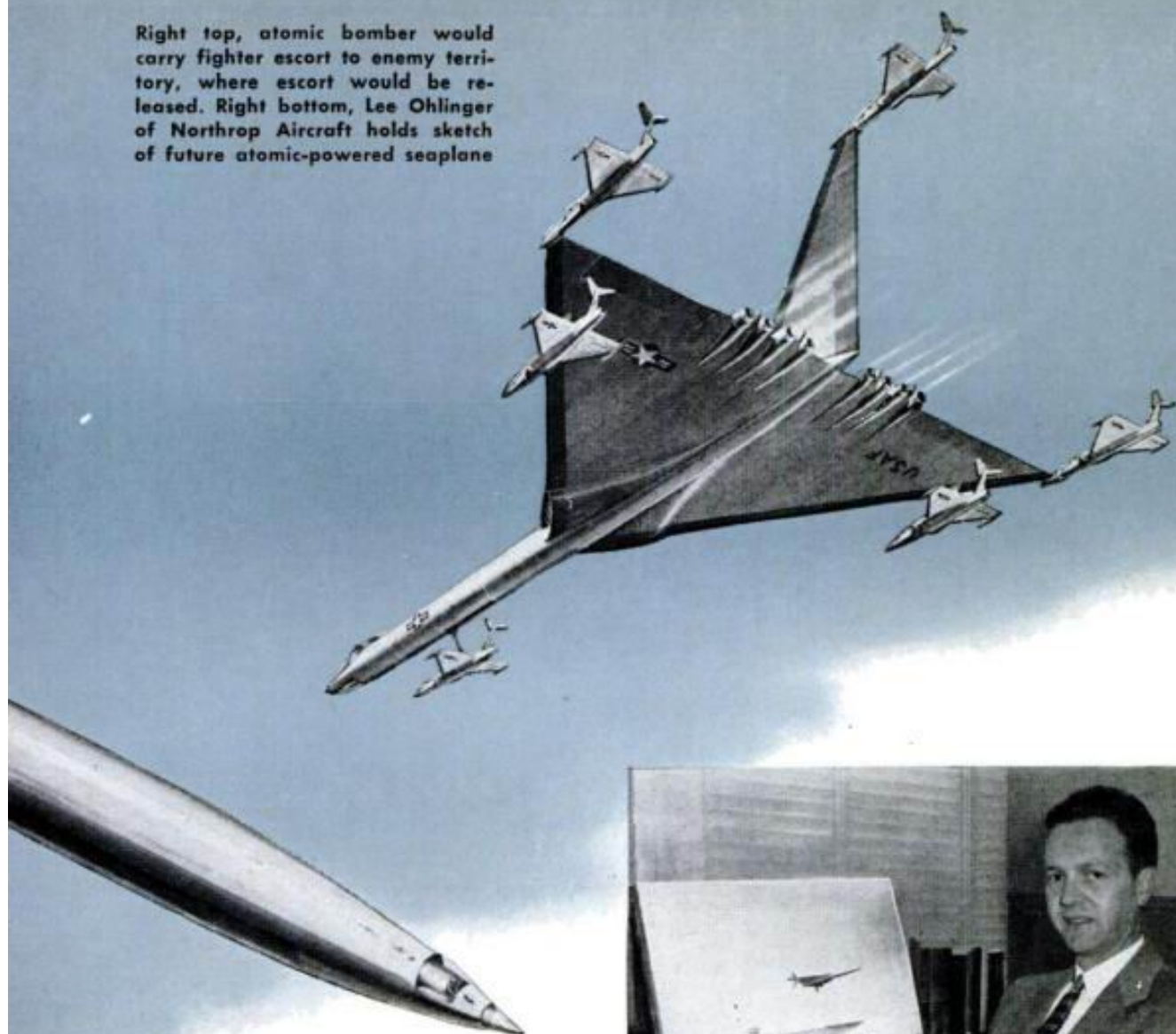
Question: What is the biggest problem in the development of the plane?

Dr. Borst: Shielding is the paramount problem. One can build jet planes that will work; one can build a reactor that will provide the heat and the power. But whether one can put a suitable shield around the reactor is the big question. Research reactors generally have shields between 5 and 10 feet thick. They are all made of concrete with special ingredients, which makes the concrete both very strong and very heavy. But these massive shields run up to 200 tons, which is much too heavy for an aircraft. So newer and more dense materials will be used.

Question: Can you give estimates on the size and weight of an airborne reactor?

Dr. Borst: The reactor could be a three or four-foot sphere. It would contain uranium, probably a moderator to slow down the neutrons, and would require a cooling system which would have to be large and elaborate. Taking that much heat out of a three-foot sphere is a difficult job. That combination would perhaps weigh a few tons. Then we would need pumps to circulate the cooling material between the reactor and the jet engines. That would take a few tons. Then, if you put a shield around the reactor, the total power package runs close to 50 tons, and would probably have a diameter of something between 10 and 15 feet. There might be a little more shielding in the direction of the crew.

Right top, atomic bomber would carry fighter escort to enemy territory, where escort would be released. Right bottom, Lee Ohlinger of Northrop Aircraft holds sketch of future atomic-powered seaplane



Mr. Ohlinger: I would bet it's more likely to be cylindrical, to facilitate getting out the heat.

Question: Will the shielding problem dictate any unusual features in the crew's quarters of a nuclear airplane?

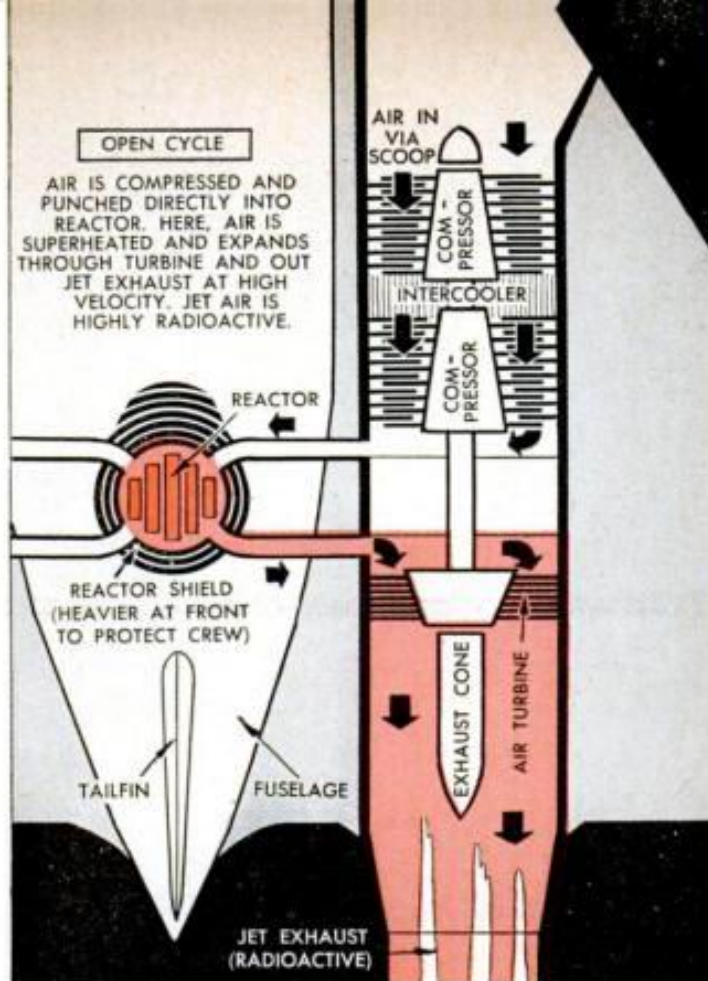
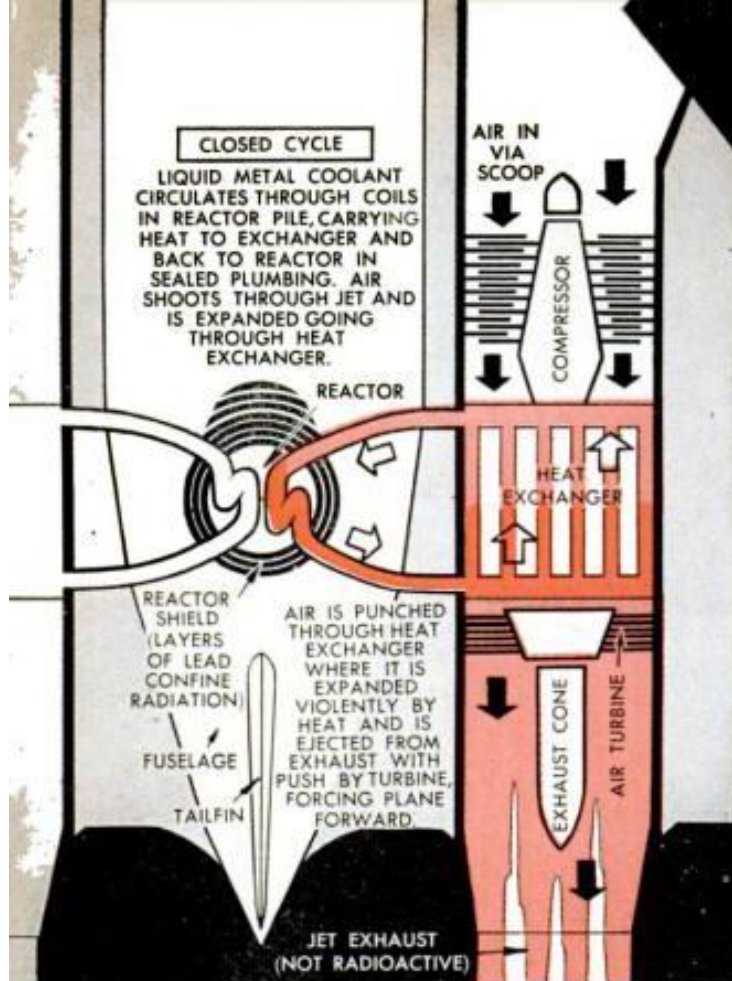
Dr. Borst: To minimize shield weight, there would probably be an advantage to putting part of the shielding at the reactor, and part around the crew. Since the crew wants to be as far from the reactor as they can get, the plane would be built to get them far away. And crew quarters would have to be as small as possible to minimize the weight of the crew shield. So, one thinks sometimes about what is practically a flying arrow, with the reactor near the tail feathers and the crew near the arrow head. One would probably not want to use a crew of more than three and they would be very confined; they would not have walkways, galleys, bunks or anything like that. We may be going back to the very

old planes, where you had tandem cockpits.

Question: How far from the reactor will the crew have to be?

Mr. Ohlinger: This is related to the amount of shielding around crew and reactor. The farther away we put the crew, the more fuselage is required. Therefore, we must balance the additional weight of fuselage against the weight of shielding required if the fuselage were shortened, and make some compromise. Reaching out into the blue, one might guess the separation distance at not less than 20 feet nor more than 100 feet.

Question: Is there any advantage in having the crew's cabin in a wing tip, or the tail fin as you have proposed, Mr. Ohlinger?



Diagrams compare the closed-cycle and open-cycle reactor systems. Open-cycle system has radioactive exhaust

Mr. Ohlinger: Wing-tip pod locations for crews are not practical except in straight, level flight. The only practical locations are in the extended nose of the fuselage or in an elevated, extended position in the tail.

Question: How long would crewmen be in their compartment on a 14,000-mile round trip?

Dr. Borst: At the speed of sound, that works out about 18 hours.

Question: What will it be like for a crew flying the first atomic plane?

Mr. Ohlinger: Flying the A-plane should be simpler because we have power to spare and can operate our plant more leisurely.

Question: Will the crew be completely shielded from all radiation, or will they take doses of radiation within allowable tolerances?

Dr. Borst: They can't possibly be shielded from all radiation. The next part to the question involves a military judgment as to how much radiation you permit the crew to take in order to improve the performance of the plane. If you want to improve crew protection, then the weight of the plane rises, maneuverability diminishes and it is a less-good fighting weapon. So military engineers must define their objectives and their permissible radiation levels. The radiation that a crew can take is a design factor, like range, speed and bomb load.

Question: How much radiation can a man take safely?

Dr. Borst: The National Academy of Sciences has determined that the average person reaching maturity has taken between 5 and 10 roentgens of radiation. Ten roentgens per trip by A-plane would seem to be acceptable. Generally speaking, 400-R is considered deadly. Half of those who receive 400-R will die, half will live.

Question: Will radiation impose any problems on the mechanical structure of the airplane?

Dr. Borst: It is true that lubricating oils turn to tar under reactor radiation, and in some cases metals deform and lose their original strength. You keep the materials which deteriorate in a place where the radiation level is low. This means that no lubricant can be used inside the reactor itself. All bearings must be outside, unless a solid lubricant, such as a graphite slideway, were used. Glass and ceramics cannot be used. Plastics are not a possibility for permanent parts. So one has to build the structure primarily out of good metals. But the technology that is being developed for the power industry is directly convertible, and the information serves just as well for this plant.

Question: Will any unusual configurations be imposed by the power source on things such as shape of airfoils, landing gear and the fact that there is no weight loss in flight due to fuel consumption?

Mr. Ohlinger: The power source will have

little or no effect upon airfoil shape, which is dictated by the performance of the overall airplane. There is no reason to believe that the first nuclear-powered plane will be exclusively powered by atomic energy. It is possible that take-off and landing would be by conventional combustion power to reduce the nuclear-power-plant size and the danger of ground contamination or ground-crew irradiation. Since the landing weight is as great as the take-off weight, the landing field probably will be large—as indicated by the special strip for nuclear-powered planes in Idaho.

Mr. Teichmann: If you are going into high speed, you need an airfoil designed for high-speed considerations. You would have a sharper leading edge than the normal. The wing would probably incorporate devices to reduce speed for landing purposes, such as boundary-layer control, or flaps or other high-lift-increase devices. This airplane has to land at a speed the pilot can handle, so the wing must be large, or have unusually high lift capacity. And since there is no loss of fuel weight in flight, we will need a more rugged landing gear, with perhaps many additional wheels to distribute the load on runways.

Question: Might this be so difficult that this would become a seaplane?

Mr. Teichmann: Yes. In a seaplane we would distribute the load over a larger area, which would permit a slightly lighter structural weight for the aircraft itself. And we wouldn't have to worry about

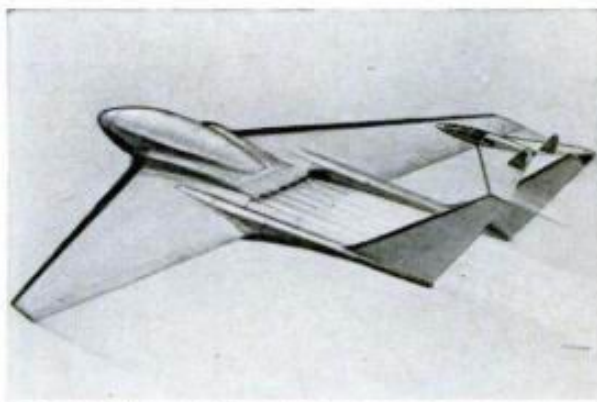
the thickness or the length of the runway.

Question: What do some proposed A-plane designs look like, and how do they work?

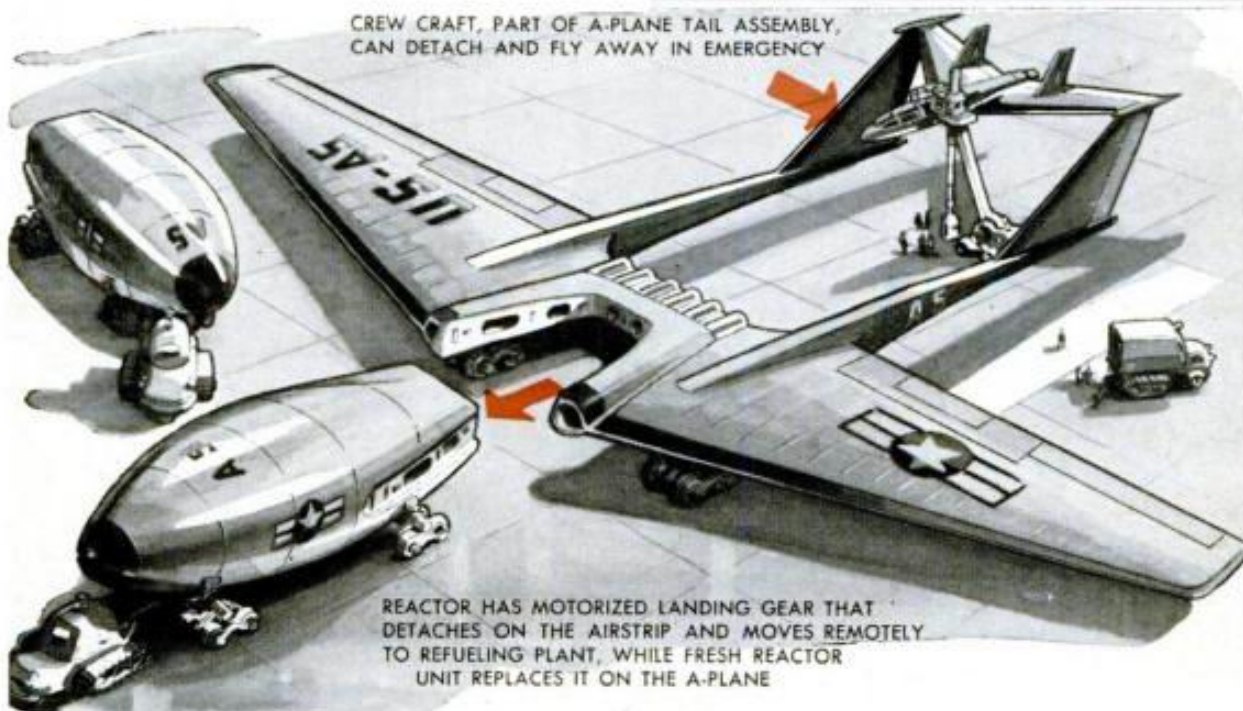
Mr. Teichmann: Grover Loening has suggested a huge seaplane. It might be compared to a flying aircraft carrier with a flat deck for the smaller airplanes to land. It has disappearing elevators, to carry planes up from and down to the storage hold.

Mr. Ohlinger: A nuclear-powered towing plane could perform the function of a sky locomotive circling the globe. It would ferry freight, with parachute-drop unloading. It could tow passenger planes with large pay loads and only enough fuel to take off and cruise, until they hooked on to the big atomic plane for a ride. At destination the small planes would cut loose and land. You might even transfer crews, using shuttle planes and retractable locks. This same concept can be extended to an aerial tanker that carries a group of jet fighters to a combat theater and then stays aloft to refuel the fighters.

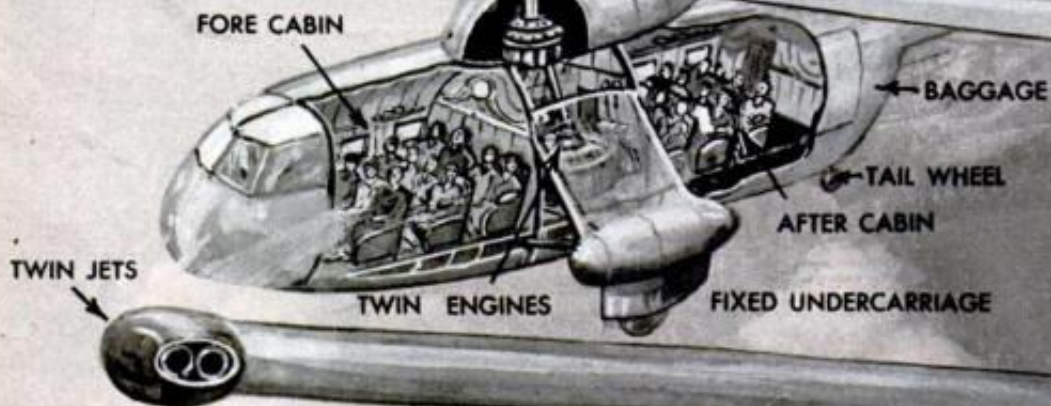
(Continued to page 258)



Artist's sketch of an A-plane conceived by Ohlinger of Northrop Aircraft (also on cover in full color) shows one solution for replacing the atomic reactor



W-80
20 TO 24 PASSENGERS



W-85

CARRIES 100 TROOPS
OR 68 PASSENGERS
15-TON PAYLOAD
TYPE MAY MOUNT
THREE-BLADE ROTOR
WITH TWIN-JET ENGINES
ON EACH BLADE OR
SIX-BLADE ROTOR
WITH SINGLE ENGINE
ON EACH BLADE

TWIN
ROTORS

REAR RAMP

TWIN WHEELS

FUEL TANKS

FOUR-BLADE ROTOR

TWIN-JET ENGINES

ENTRANCE
AND BAGGAGE
REST ROOM

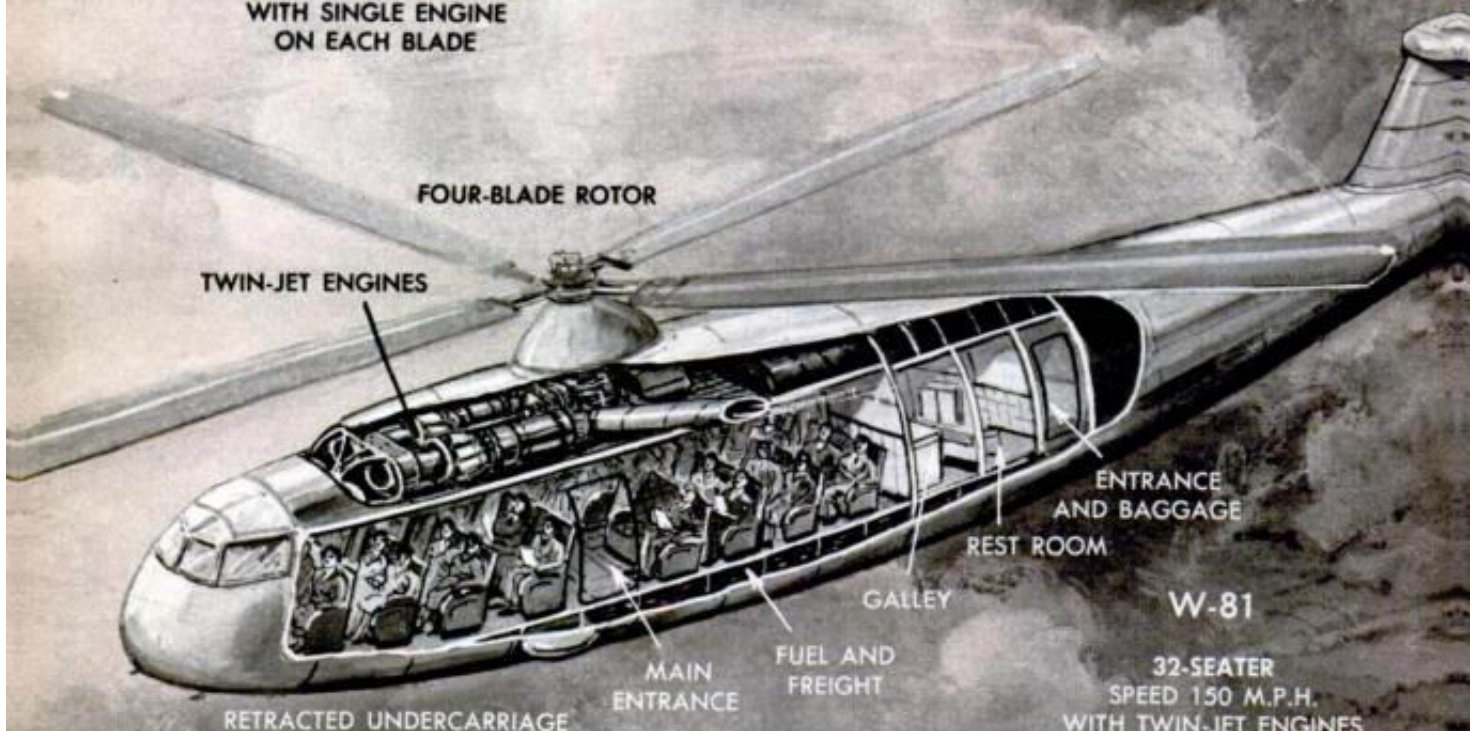
GALLEY

MAIN
ENTRANCE
FUEL AND
FREIGHT

RETRACTED UNDERCARRIAGE

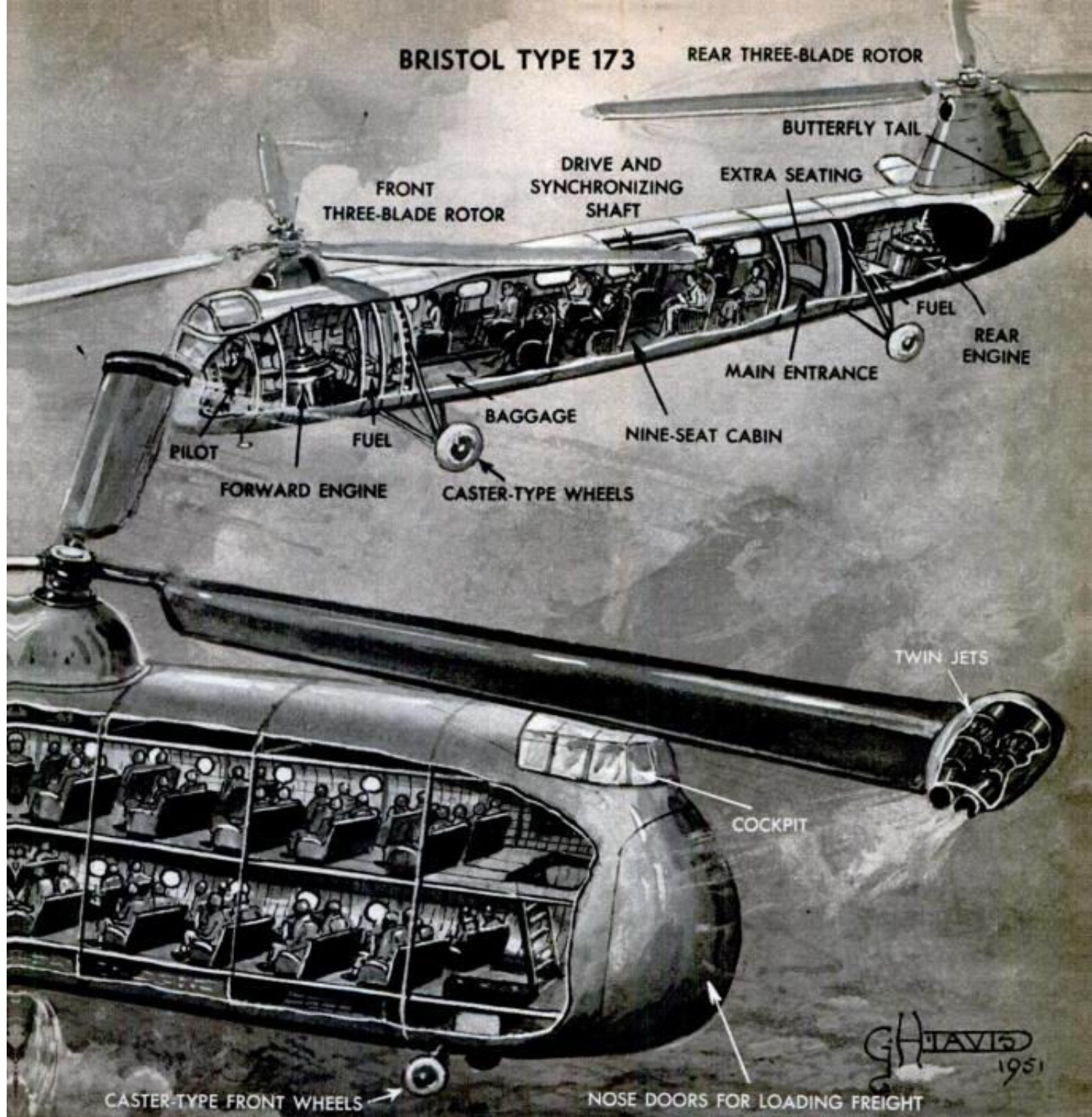
W-81

32-SEATER
SPEED 150 M.P.H.
WITH TWIN-JET ENGINES



BRISTOL TYPE 173

REAR THREE-BLADE ROTOR

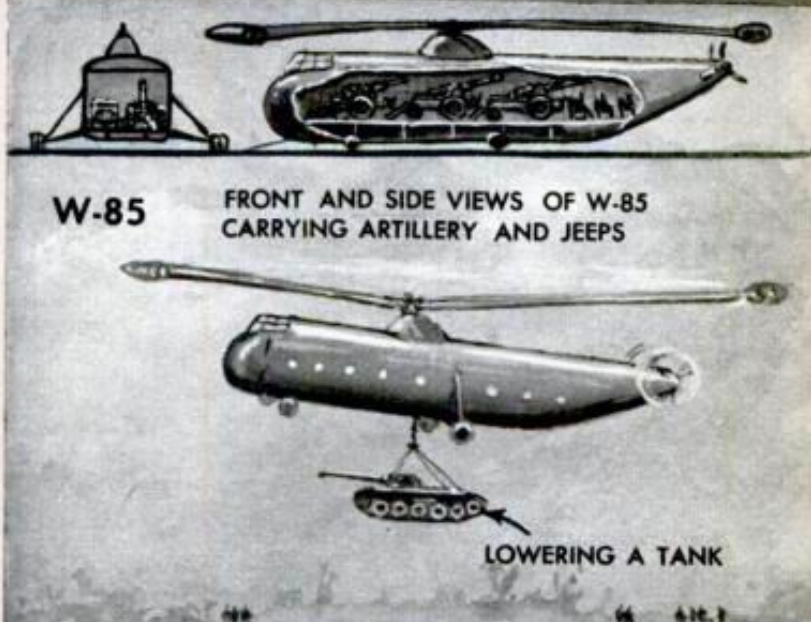


Helicopter Forecast From England

Several experimental helicopters have been built in England or now are in the design stage. Type 173, shown at top of page, has two motors to power the two rotors. Should either motor fail, the other can be used to drive both rotors. The W-81, at left, has two turbojet units, placed side by side, which are expected to give the aircraft speeds up to 150 miles per hour. The huge W-85, above, is designed to airlift about 100 troops in military use

MARCH 1952

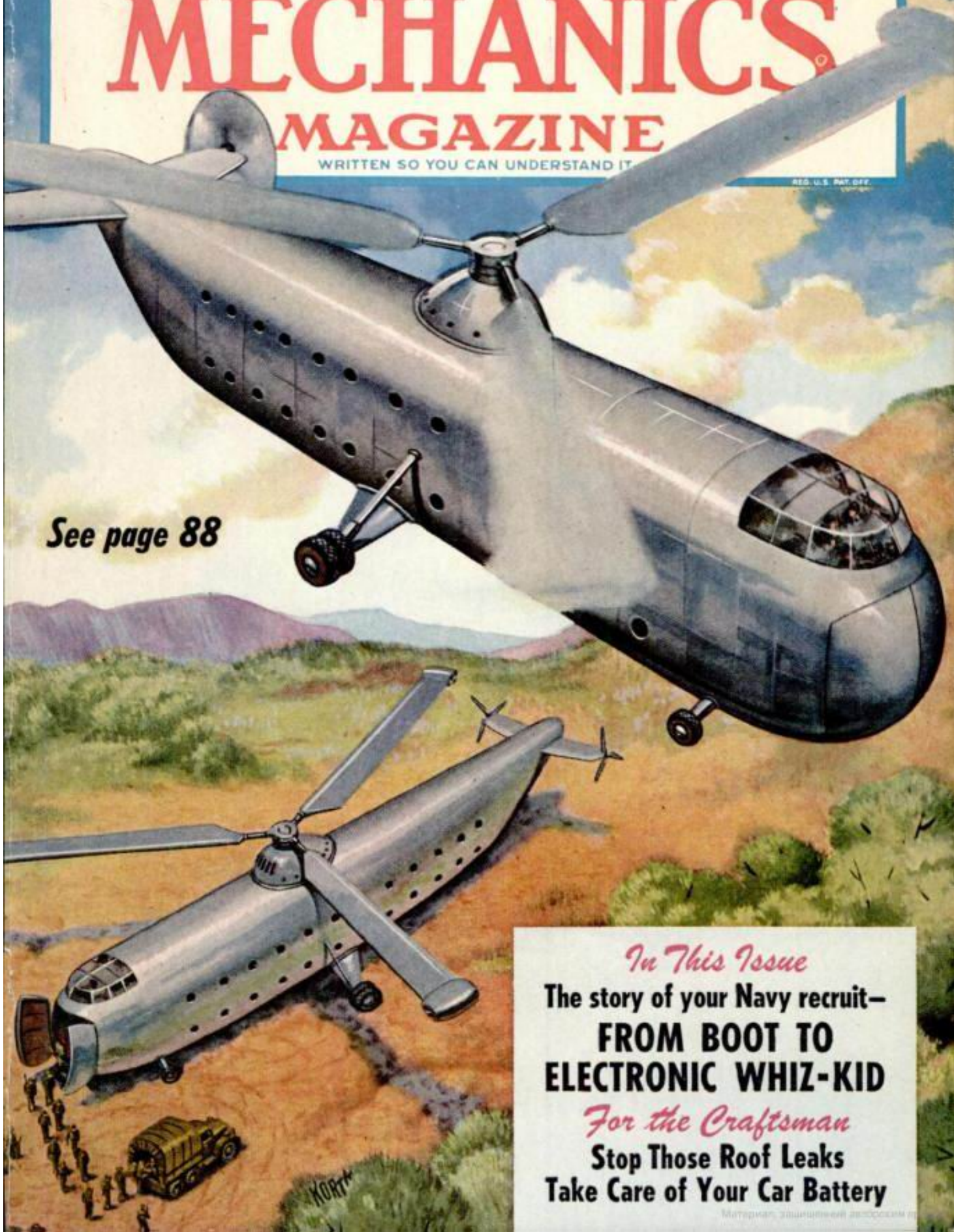
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See page 88

In This Issue
The story of your Navy recruit—
**FROM BOOT TO
ELECTRONIC WHIZ-KID**

For the Craftsman
**Stop Those Roof Leaks
Take Care of Your Car Battery**

Material: защищенный автомобиль

HUNTING THE SECRET OF LIFE

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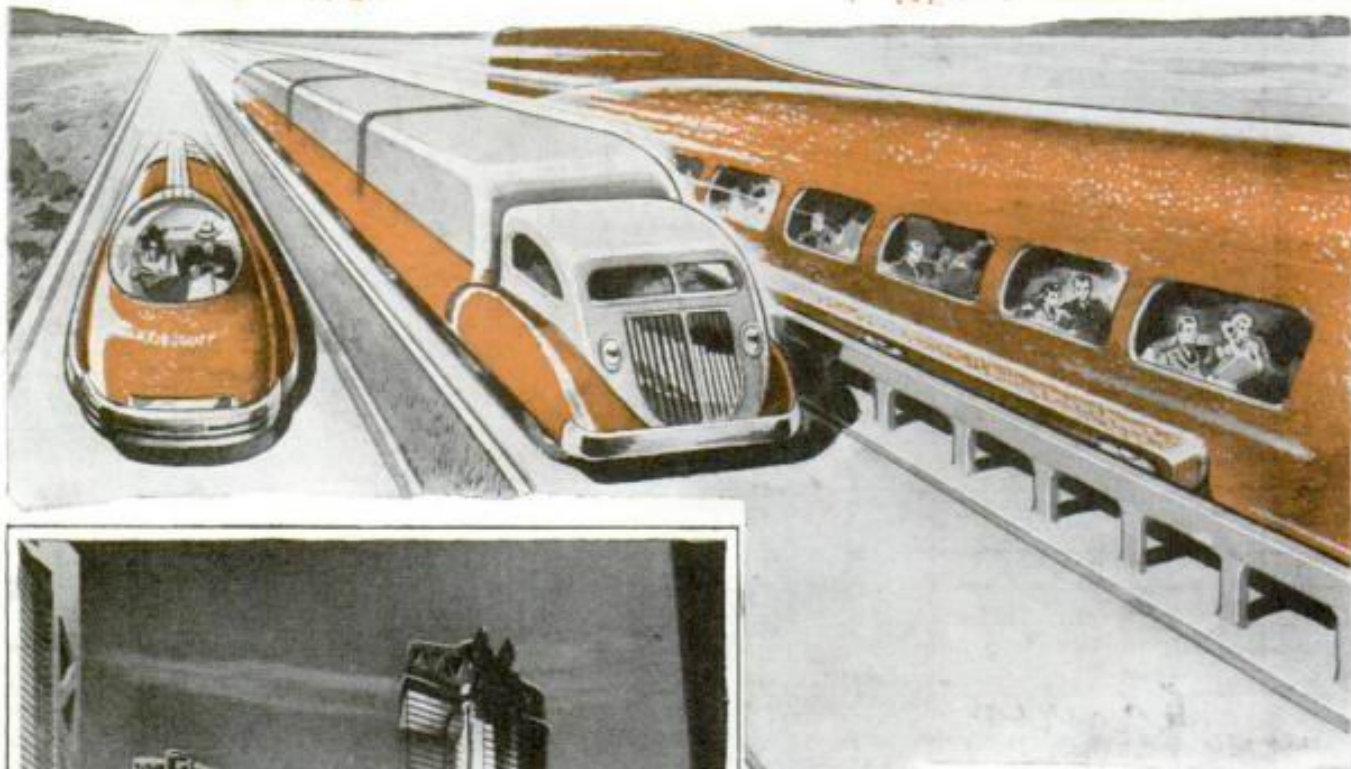
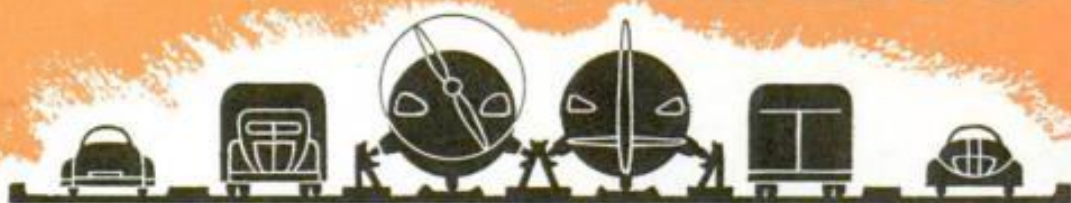
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SEE PAGE 808

B. A. de

PLANNING *the*



Drawing of transportation system suggested by the author. Above, six-lane system in silhouette. Left, future metropolis as designed by Mr. Teague for U. S. Steel exhibit at New York World's Fair



By Walter Dorwin Teague

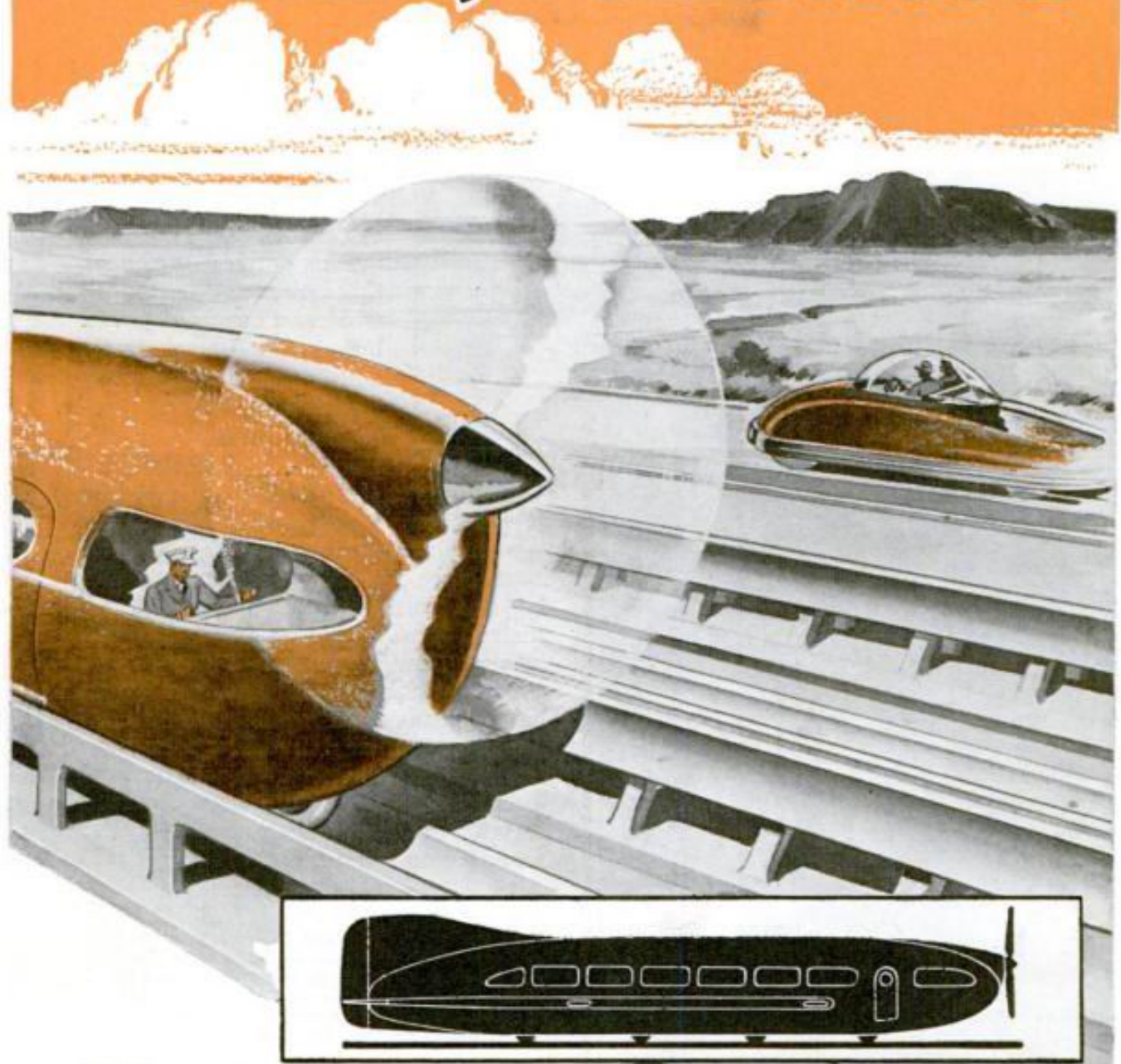
Industrial Designer and Author of "Design This Day; The Technique of Order in the Machine Age," published by Harcourt Brace

444 modern life nyc
A BETTER world than we have ever known can and will be built. But the builders must feel into the future, groping carefully, ready to adapt their plan, at any moment, to new truths and unforeseen conditions that may be revealed as they progress.

Our better world may be expected to make equally available for everybody such rare things as interesting, stimulating work,

K916

WORLD of TOMORROW



emancipation from drudgery and a gracious setting for daily life, freedom of movement, free exchange of thought, bodily well-being and mental equanimity. But since even such simple conveniences as modern kitchens and bathrooms have not yet become general in America, attainment of these more difficult objectives by a majority of our people is far in the future.

The reform of our railroads is certainly among the most pressing problems confronting us today, because our social and economic system, if it persists, will continue to be based on the free movement of goods and men. Railroads maintain broad

Note that the rail car travels on a single wheel, with supporting wheels at either side. Inset, the car in silhouette. Note tail fin which would make for stability at high speed



units of relatively small size and low cost, powered by internal-combustion engines and borne on rubber tires. These privately operated, specialized highways then could perform a service which the public highways cannot perform and would relieve public highways of a vast load of commercial traffic.

The center lanes of these reborn "railroads" would be concrete-paved but steel-walled channels which would carry very high-speed traffic. Torpedolike vehicles, automatically controlled,

would be shot through these channels at speeds only reached by airplanes now—perhaps in excess of 200 miles per hour, since necessity for human steering and control would be eliminated. Instead of a Twentieth Century Limited leaving New York once a day for an overnight trip to Chicago, we would have capsules of a manageable size departing on their breathless four-hour runs at hourly intervals, or oftener.

These vehicles would have teardrop forms. An airplane motor and propeller mounted on the nose might be the mo-

(Continued to page 158A)

Top, author pointing out to his son, a graduate engineer, details of house appliance in the modern styling. Left, radio tower in "Farm of the Future" diorama at U. S. Steel exhibit. Below, another view of the future metropolis with multi-level traffic systems and multi-story buildings



rights-of-way that usually are the shortest lines through the densest concentrations of population. These rights-of-way are almost gradeless as compared with automobile highways, they have no sharp curves and they are becoming free from obstruction by cross traffic. Suppose these rights-of-way were paved with concrete from edge to edge. Suppose they were divided into traffic lanes for varying services, and all their passengers and freight were carried in light powerful



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Blueprint for a

POPULAR JULY 1949
MECHANICS

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VOL. 92 NO. 1

Passenger Rocket

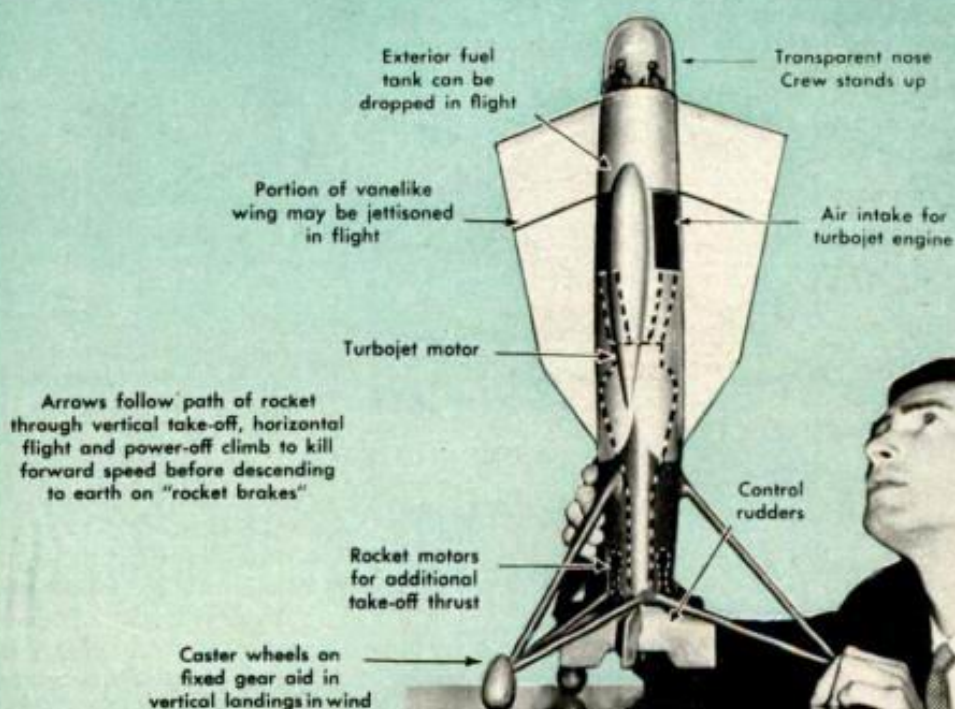
By Thomas E. Stimson, Jr.

A WINGED ROCKET that carries a crew of two in its transparent nose has passed its initial tests in model form and can be built at any time. That's the assertion of Stanley Hiller, Jr., West Coast helicopter manufacturer, after months of research in which the rocket and its control system were developed.

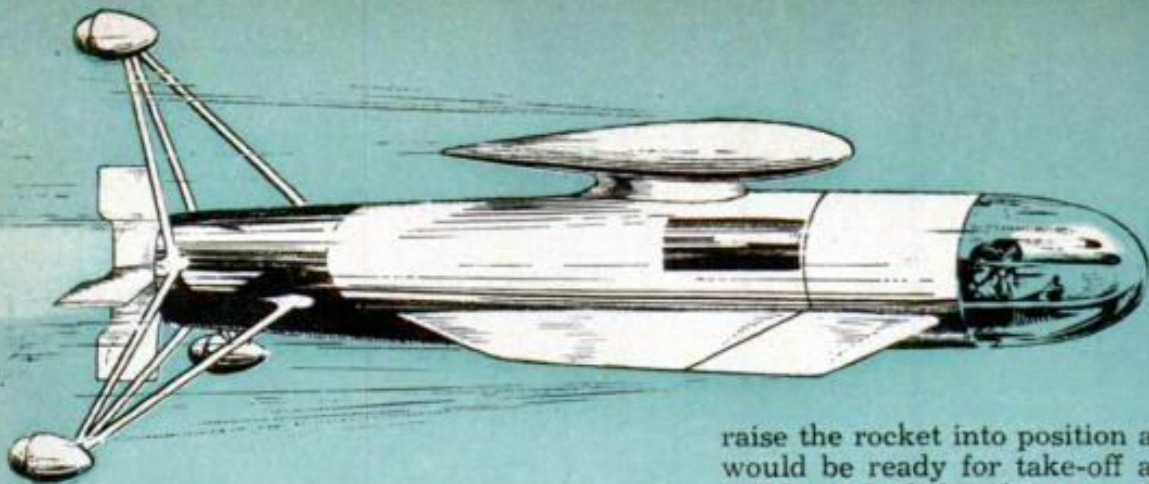
The man-carrying rocket would rise straight up from the ground, lie over on its side to fly and maneuver like an airplane at speeds up to 600 miles per hour, and would "back down" against its motor thrust to land gently on a three-point landing gear attached to its tail.

The proposed full-size vehicle would be 30 feet tall. It would resemble a V-2 rocket with a pair of small vanelike wings and a fixed landing gear attached. Two exterior streamlined drop tanks would carry sufficient fuel for one hour of flight and could be detached from the rocket in flight when emptied. Additional fuel would be carried inside the rocket's body.

The VJ-100 would be powered with a 6000-pound-thrust Rolls-Royce

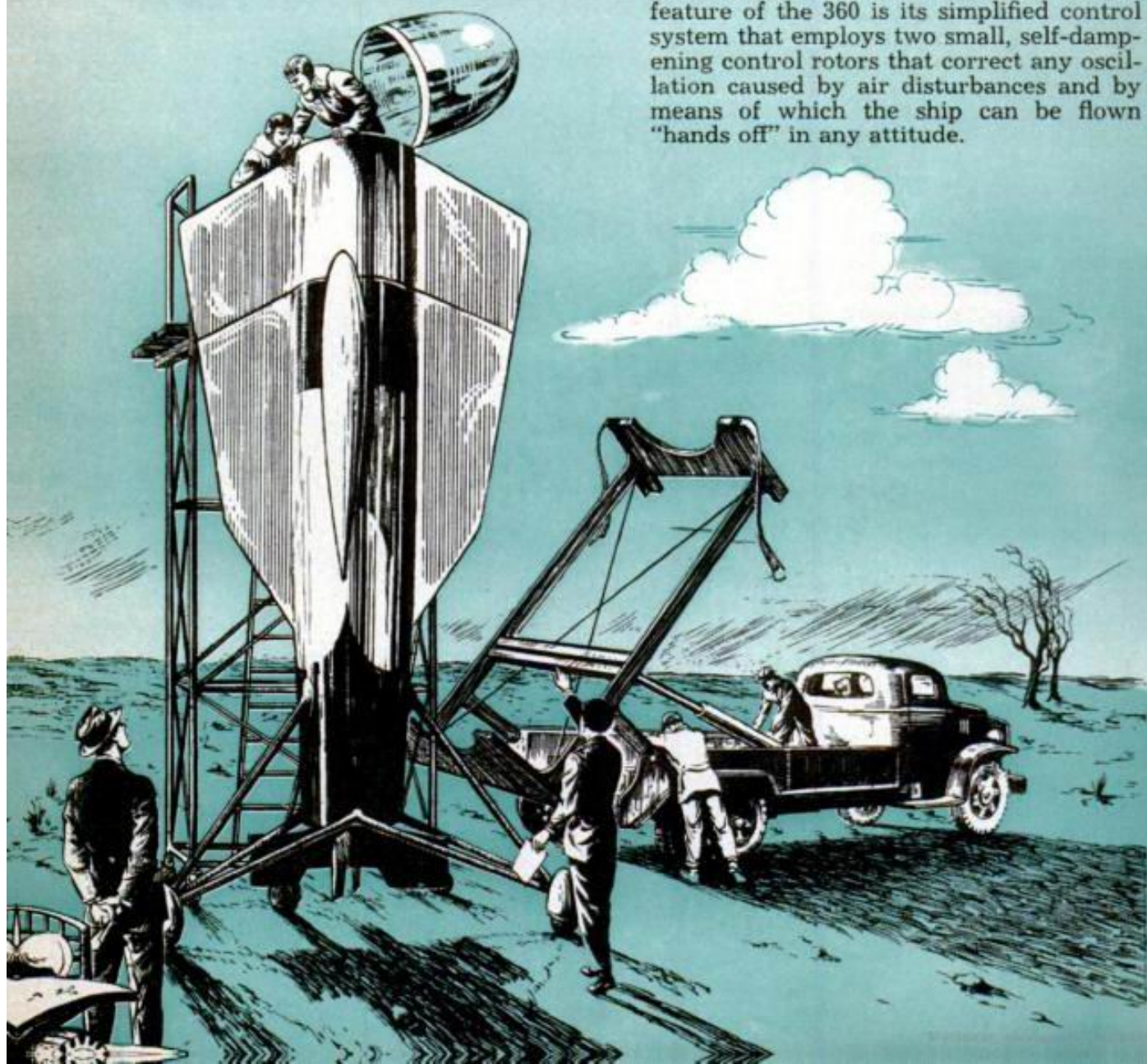


Stanley Hiller, Jr.



Above, after vertical take-off, with crew standing upright, craft is put over on its side for level flight on single turbojet engine. Landing gear would stay in fixed position

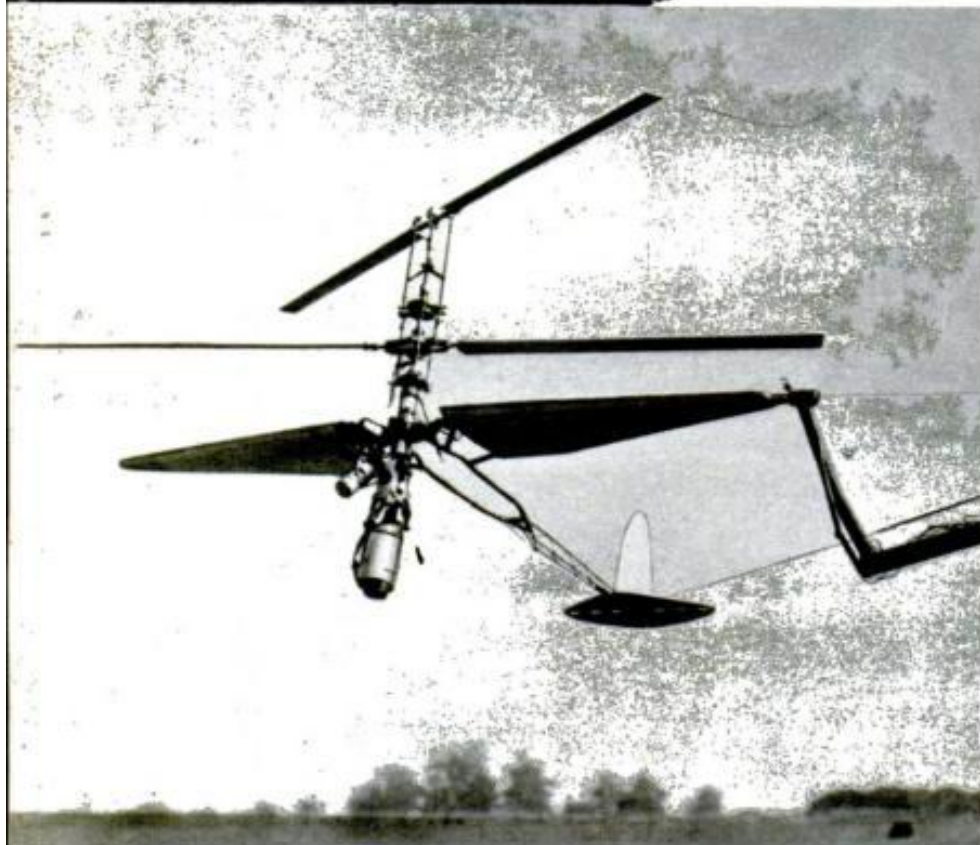
Below, man-carrying rocket could be unloaded in this fashion for photo-reconnaissance assignment. Any flat field with radius of 25 feet could be used as temporary operating base



raise the rocket into position and the craft would be ready for take-off as soon as it had been fueled and its crew had climbed on board. Any flat piece of ground with a radius of 25 feet would be suitable as a launching and landing platform.

In addition to conducting an intensive research program, United Helicopters is in production of the Hiller 360 helicopter at the rate of one ship every other day. Carrying 3 people, the 360 has a top cruising speed of 84 miles per hour, a ceiling of 9900 feet and can cruise for 2½ hours.

As a duster or other cargo-carrying vehicle the 360 can carry a pay load of 551 pounds in addition to the pilot plus sufficient fuel for an hour of flight. One unique feature of the 360 is its simplified control system that employs two small, self-dampening control rotors that correct any oscillation caused by air disturbances and by means of which the ship can be flown "hands off" in any attitude.



Hiller's man-carrying rocket stemmed from research with craft above. It resembled conventional plane but had overhead rotor blades for both upward and forward flight. Below, blades tilted for forward motion. Craft's motor was swung back into fuselage to maintain proper center of gravity



"Nene" turbojet engine and four liquid-fueled rocket motors. The latter, firing through the tail, would provide 5000 pounds of additional thrust for lifting the 11,000-pound craft vertically from the ground. The rocket could accelerate vertically at speeds up to 4.8 feet per second. Since air is required for operating its power plant, the craft would not be a space ship that could leave the earth's atmosphere.

After attaining altitude and speed, the booster rockets are shut off and the craft is laid over on its side for cruising on its turbojet. The vestigial wings have enough surface to provide full lift for horizontal flight at speeds above 200 miles per hour. They also serve as stabilizers when the craft is being backed down to a landing.

Both the pilot and passenger are strapped side by side in a standing position in the nose for the ascent, and lie prone when the craft is in level flight. Cockpit controls similar to those of a conventional helicopter are used for all maneuvering.

To prepare for a landing, the pilot reduces the power and points the rocket's nose upward in a climb that kills his forward speed. He then backs down to the ground at a controlled rate of descent, using blasts of the turbojet or the rocket motors to almost equalize the pull of gravity.

Tests have shown that there are no difficult control problems in holding the rocket balanced in a vertical position during the descent. Provision is made for jettisoning the cockpit capsule and the forward part of the wing during flight, after which the crew would descend by parachute. This emer-

gency measure is common to most aircraft in the 600-mile-per-hour speed range.

Design of the rocket is the outcome of research by Hiller's company, United Helicopters, Inc., of Palo Alto, Calif., to create an air vehicle that has an exceedingly high ratio between top speed and landing speed. This ratio is only five or six to one for the fastest conventional aircraft.

The first attempts to improve this ratio were embodied in a "convert-a-plane," a craft resembling a conventional airplane and equipped with a pair of overhead coaxial helicopter rotor blades. These blades would lift the craft up from the ground to a desired altitude and would then be tilted forward to operate like ordinary airplane propellers for producing forward flight.

Models of the convert-a-plane were put through exhaustive runs on dynamic test stands. Though the idea proved feasible, it was dropped because of several complications, including the mechanism required for changing from helicopter to fixed-wing operation.

Jet propulsion seemed to be a simpler idea because the same jet can be used to provide vertical lifting force and the thrust required for forward flight. Jet-powered models were studied both on test stands and in free flight, with results indicating that the basic design of the rocket, its power plants and control system are practical.

Hiller foresees one potential use of the VJ-100 as a high-speed military photo-reconnaissance aircraft that could be towed on a trailer to any desired operating point. An elevator on the trailer would



Operated by middle man in background, test stand forerunner of VJ-100 tilts over on its side and flies in circles. Experiments indicated ship had enough stability to back safely down to earth, at low speed, against the jet thrust. Below, the model whirling around stand in level flight



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REGD. TRADE MARK, GREAT BRITAIN, NO. 60426

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Our Newest JET BOMBER...

an artist's conception
of the delta B-58

—See page 89



What's it like to own a \$10,000 car?
Read the OWNERS REPORT on the
CONTINENTAL MARK II

ANTARCTIC ALBUM

Eight pages of color photographs
from the bottom of the world

How to take pictures indoors
without flash

Soon to emerge from secrecy in a Texas aircraft plant is the first of the delta-winged bombers, shown on this month's cover. From the interceptor to the B-58 and the atom bomber, this is the



ERA OF THE FLYING TRIANGLES

THE DELTA CHASE PLANE was just getting off the ground at Palmdale almost 150 miles away when Bob Myrann climbed into the new F-102A at San Diego, Calif., and started his cockpit check.

All the instruments checked out and Myrann got his engine started. By then the chase plane was calling him.

"787, this is Rex Warden in 995. I'm just passing Santa Anita race track. You all ready to roll? Over."

"Okay, okay, 995, let's go!" Myrann responded. He taxied out to the far end of the runway, got his take-off clearance and ran the turbine up to full military power. Then he released the brakes and cut in the afterburner. The plane howled down the runway, flared off the concrete, and Myrann pulled it up in a steep climb that would have stalled a piston-engine fighter.

Meanwhile Warden was getting into position. He had flashed across Orange County, started letting down over Escondido, Calif., and had made a big sweep of San Diego. By the time Myrann was airborne, Warden was right on his tail.

Sending a delta chase plane to accompany another delta isn't done every day, but the incident makes a graphic

By
Thomas E. Stimson, Jr.

Hottest of present operational fighters is the delta-winged F-102A, pictured above as its landing gear is retracted after take-off. Below, tail view of the F-102A shows extended speed brakes just above jet outlet. A drag chute is also used to slow plane for landing



demonstration of how fast the new supersonic interceptors can fly. Warden had taken off from Palmdale and reached San Diego in the same time Myrann needed for a cockpit check and a normal take-off.

The deltas are a new family of aircraft. They get their name from the fourth letter of the Greek alphabet, an equilateral triangle, that the new shape somewhat resembles. The delta has been called the wing of the future for aircraft that fly faster than sound. It isn't very efficient at slow speeds, but it goes through Mach 1 with hardly a tremor—then it's hard to catch. Many designers believe that its margin of superiority widens rapidly as the speed goes up. It is said to be more stable and maneuverable than other designs at high altitudes.

"The delta wing gives an interceptor pilot a tremendous advantage at altitudes of around 50,000 feet," says Warden, chief test pilot at Convair's Palmdale, Calif., facility. "A delta can overtake any bomber that has been built so far. If the bomber pilot tries a tight turn in the thin air he loses speed and goes into a stall. He needs maybe 25 miles of space to turn around. The delta can turn much more sharply. If the bomber pilot tries to dive away, his speed goes up and he gets into compressibility. He loses control. Escape is almost impossible."

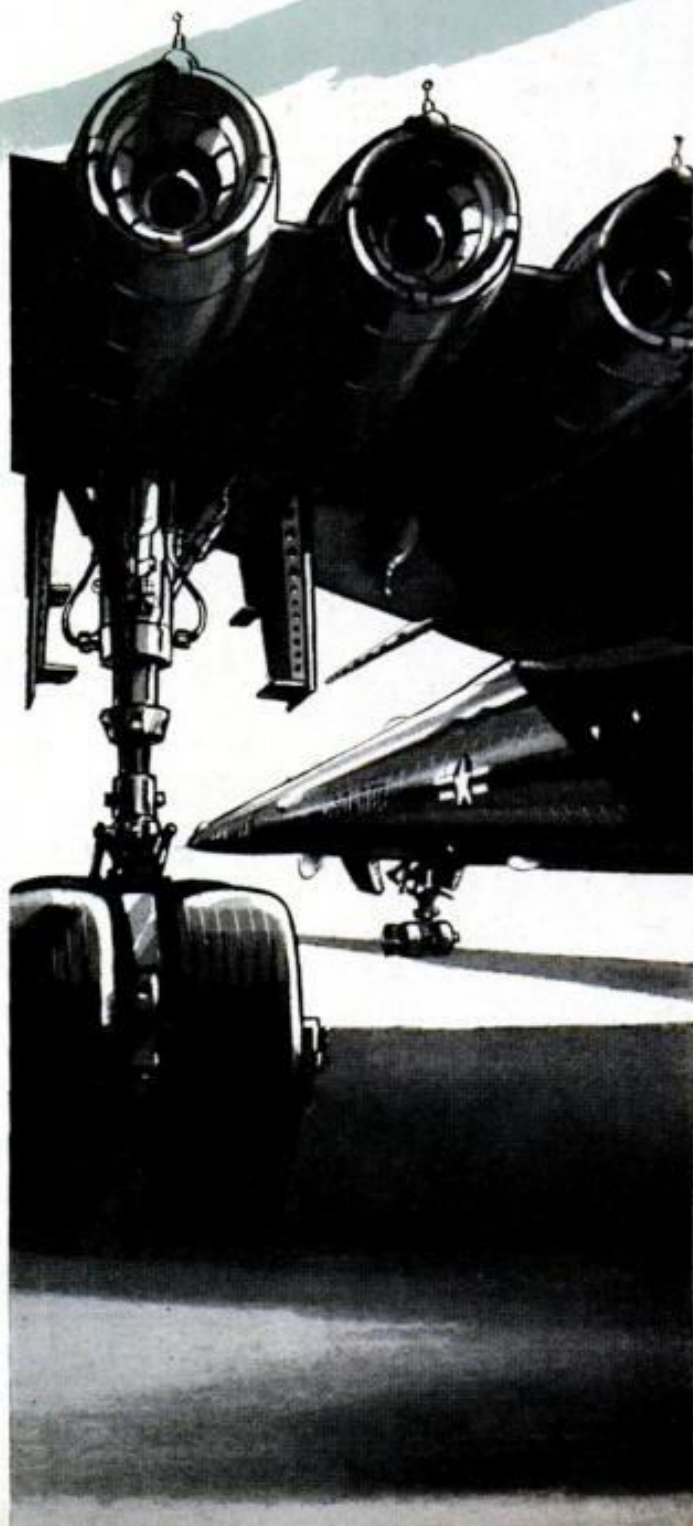
These days the F-102A doesn't even need to get close to its target to make a kill. The big six-foot Falcon homing missiles that it carries can be fired from miles away. Interception is automatic and is performed by the new Hughes "seek-find-kill" electronic system that guides the interceptor to the target. If air-to-air aimed rockets are to be fired instead of the guided missiles, the electrical brain "locks on" the target and gives steering directions to the pilot so that he flies a lead collision course. Then the system opens the missile doors under the fuselage and launches the armament at the exact instant when a kill is assured.

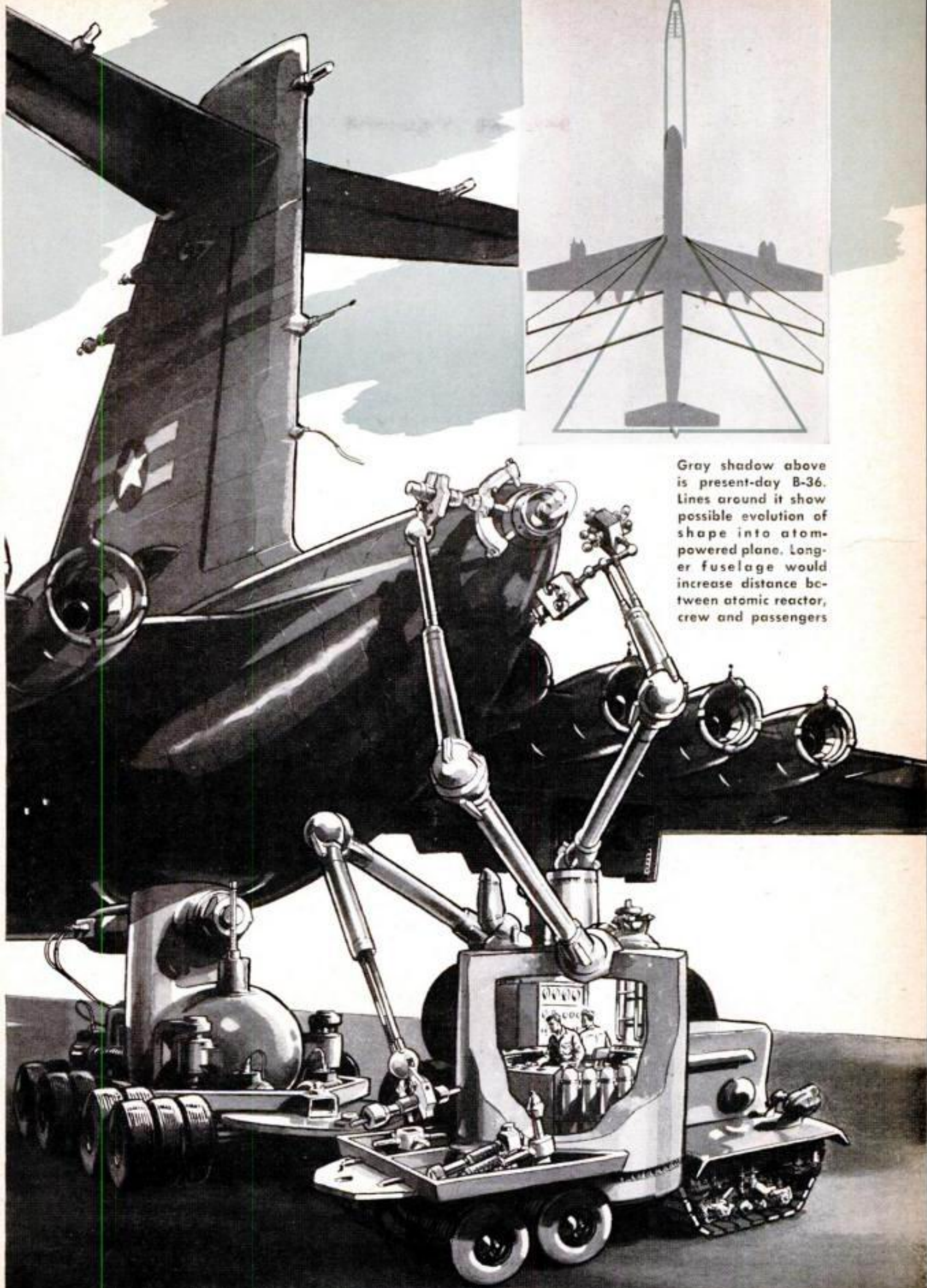
The delta configuration has so many advantages that England, Sweden, France and Russia, among others, are building delta aircraft. In the United States, Douglas is using a deltalike shape for its F4D Skyray and again for its A4D Skyhawk. Ryan Aeronautical selected the delta wing for its new X-13 Vertijet aircraft that takes off straight up. Other deltas are on the way.

The real exponent of the aircraft that is shaped like an arrowhead, however, is Convair, builder of the F-102A. Convair used the wing for its Sea Dart seaplane and also for its XFY-1, the turboprop fighter that takes off and lands on its tail. The Convair designers in San Diego regard it as the logical shape for tomorrow's planes

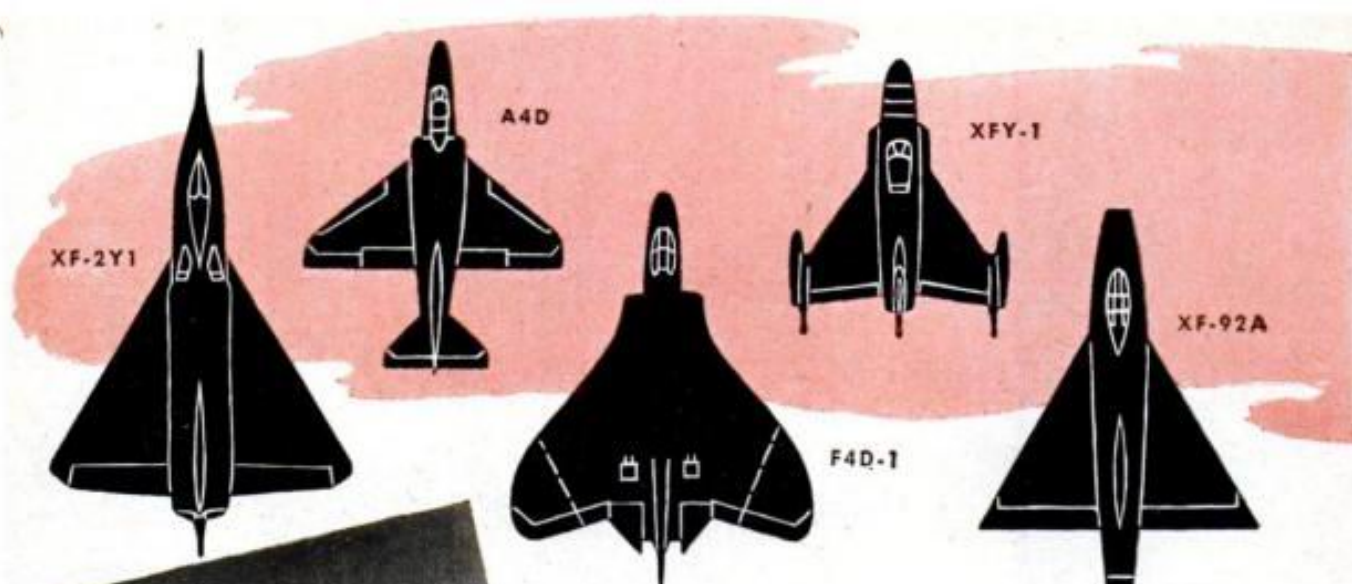
Popular Mechanics' drawing made from designs by Lee A. Ohlinger of Northrop Aviation, Inc.

Giant delta-winged, atom-powered jet transport of the future will be refueled by lead-shielded tank-like vehicles. Operators inside vehicles see through TV iconoscope cameras and do work with robot arms. Trailer under plane contains shielded coffin to receive spent but still radioactive slugs of plutonium which will be replaced with fresh fuel





Gray shadow above is present-day B-36. Lines around it show possible evolution of shape into atom-powered plane. Longer fuselage would increase distance between atomic reactor, crew and passengers



Above, plan views of planes using the delta-wing configuration or variations of it. Left, this month's cover with artist's conception of B-58 accompanied by an F-102A, to which it bears a resemblance in all but size



that are intended to fly at 1500 miles per hour or more.

It's believed that the nuclear-powered aircraft of the not-distant future will have a delta wing. The delta seems to have special advantages where atomic power plants are used.

It's a good guess, too, that the world's first supersonic bomber, the B-58 Hustler that Convair is building at Fort Worth, Tex., has the delta configuration. Our cover painting is an artist's conception of the B-58.

B-58 Will Be Big

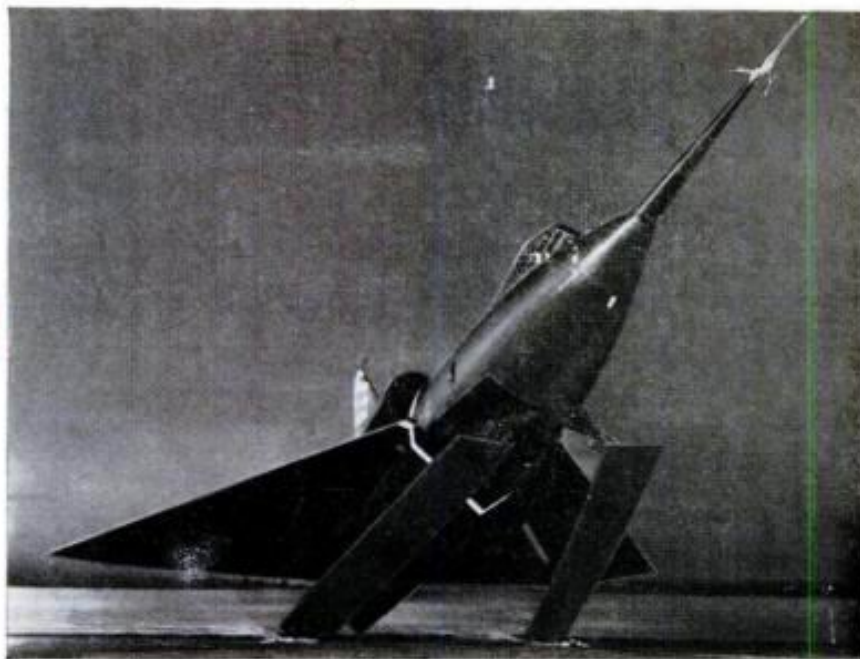
The plane likely will be similar to the F-102A interceptor which also appears on the cover. The B-58 will be big and heavy in spite of the fact that it's designed to travel faster than a revolver bullet. Its bomb bay is said to be large enough to pack an H-bomb.

The four jet pods that the artists placed below the wing may carry one or two engines each, depending on the size of the power plants. The pods are placed outboard instead of being buried in the wing because American designers consistently favor this safer location.

Honeycombed Hustler

Among other innovations in the Hustler is the considerable use of aluminum or stainless-steel honeycomb in the basic structure. Honeycomb has a desirable strength-to-weight ratio and also retains

Air turbine on F-102A is an emergency device that pressurizes hydraulic system and other controls in event of engine failure. It is extended when needed



Convair Sea Dart, billed as world's fastest seaplane, uses a delta wing. An early model is pictured. Later ones have a single hydro-ski instead of two

much of its strength at relatively high temperatures. Presumably the B-58 will operate at speeds at which aerodynamic heating will be a problem.

Special radar equipment has been perfected to allow the B-58 bombardier to release his armament with acceptable accuracy even while traveling at possibly 1000 miles per hour some 10 miles above the earth. It has been said, too, that some of the first production B-58s will carry electronic countermeasure devices. These might be improvements in the foil strips that bombers discharged during the last war to create a poor picture on enemy radarscopes, or they could be some entirely new system that would prevent enemy fighters or guided missiles from homing on the bomber.

Wing Is Thick at Fuselage

One virtue of the delta wing is that it can be fairly thick where it joins the fuselage and still have the low thickness ratio that is favored for high speed. This is possible because the wing itself is so deep, from leading edge to trailing edge. This thickness gives enough room for designing a very stiff wing, preferred for high load factors. It also provides room for considerable fuel storage.

Any delta wing has a large area, so wing loading is low. This provides the stability at high altitudes for which the design is noted. It also provides very desirable gliding characteristics. The F-102A, for instance, can deadstick to a landing strip more than 50 miles away from an altitude of 40,000 feet.

One of the reasons why the F-102A goes

through the speed of sound so easily is that it doesn't have a conventional tail group that tends to upset stability. The rudder makes up part of its large fin. Elevators and ailerons are combined in the long "elevons" on the wing's trailing edge. When the control stick is moved forward or aft the elevons operate as elevators; when the control stick is moved to one side the elevons move differentially and serve as ailerons.

Delta Is Logical Shape

The delta configuration seems to be the logical shape for the large atomic-powered aircraft that may be flying soon. Already, Convair is testing an atomic reactor in a big straight-wing B-36, though not for propulsion purposes. The preliminary research is being confined to studies of the radiation and shielding problems. Boeing and Lockheed among others also have study contracts on atomic aircraft.

At Northrop, Lee A. Ohlinger thinks that large military aircraft and possibly commercial airliners using atomic power are only 10 years away.

"From what we know today," he says, "we can expect an atomic airliner to be some 200 feet long, with a delta wing and a long fuselage. It will weigh 150 to 250 tons and will cruise at 60,000 feet at a speed of 1500 miles per hour or more."

The size and shape of an atomic aircraft is dictated by the fact that the power reactor requires some 35 to 50 tons of shielding, he explains. The aircraft has to be large to be able to lift such a dead weight.

To avoid destructive neutrons the crew and passengers must be placed as far as



An F-102A shown in an approach to a landing, with its various parts and outstanding features identified

practical from the reactor itself, hence the pressure cabin would be located in the nose of a long fuselage. For the same reason the reactor should be as far aft as possible. The center of lift of a delta wing is farther aft than in a straight or swept-wing, so the delta is the logical choice aside from its other advantages. The first few nuclear aircraft may not use the delta, but Ohlinger expects that in the long run it will be found to be the most practicable.

The weight of the shielding would be even greater except for several tricks that engineers have devised. One of these is the so-called "shadow shielding" by which the heaviest shielding is placed on the side of the reactor that faces the pressure cabin. Passengers and crew would remain in the shadow of this shielding and thus escape harm.

Atomic Power in a Plane?

How can atomic power propel an aircraft? Various ways have been suggested. The most practical solution seems to be to use ordinary jet engines in which the air normally is heated to 1600 degrees (critical temperature of the turbine blades) by the combustion of a liquid fuel. In the nuclear aircraft no liquid fuel would be used. Instead, the compressor air would be circulated through the hot reactor where it would be heated to the desired temperature. The jet thrust would be just the same as if an ordinary fuel was being burned. Actually, to avoid spewing contaminated air behind the plane, the reactor heat probably would be transferred to the engine air by a heat exchanger.

One reactor would furnish enough heat to operate as many jet engines as would be needed for propulsion. To avoid heat losses from long duct runs it is probable that the jets would be grouped closely at the center line of the plane.

From the power standpoint there's no reason why an atomic aircraft can't be designed to fly at a speed of, say Mach 5, or about 3500 miles per hour. Aerodynamic heating would be offset by refrigeration.

It's quite possible that the ultimate atomic airliners will be able to cruise around and around the earth, staying aloft for weeks or months at a time. Passengers would arrive and depart over various cities by means of shuttle planes that would nose into a retractable air lock under the fuselage. Crews would be changed and supplies brought aboard by the same means. Only when the atomic reactor itself needed servicing would the big transport need to land.

Servicing a Problem

In servicing the plane, no one without protection would dare approach the area where the reactor is located. In fact, after a number of landings the service area of the airport itself could very easily become contaminated.

To service the reactor, a vehicle something like an armored tank with the mechanics sitting inside a shielded turret probably would be needed. They would use periscopes and TV screens to watch their work, which they would perform by operating big mechanical arms.

In such a vehicle they could move up to the rear of the aircraft, unscrew the cover plates and unload the fuel elements that needed to be replaced. These fuel cans would be dropped into a portable "coffin" located on a trailer towed by the service vehicle. Using the same robot arms, the mechanics then could load new elements into the power plant. The reactor would be designed so that any kind of servicing could be performed by the remotely controlled robot arms, including replacement of the entire reactor. ★ ★ ★

JULY 1957

35 CENTS

POPULAR MECHANICS MAGAZINE

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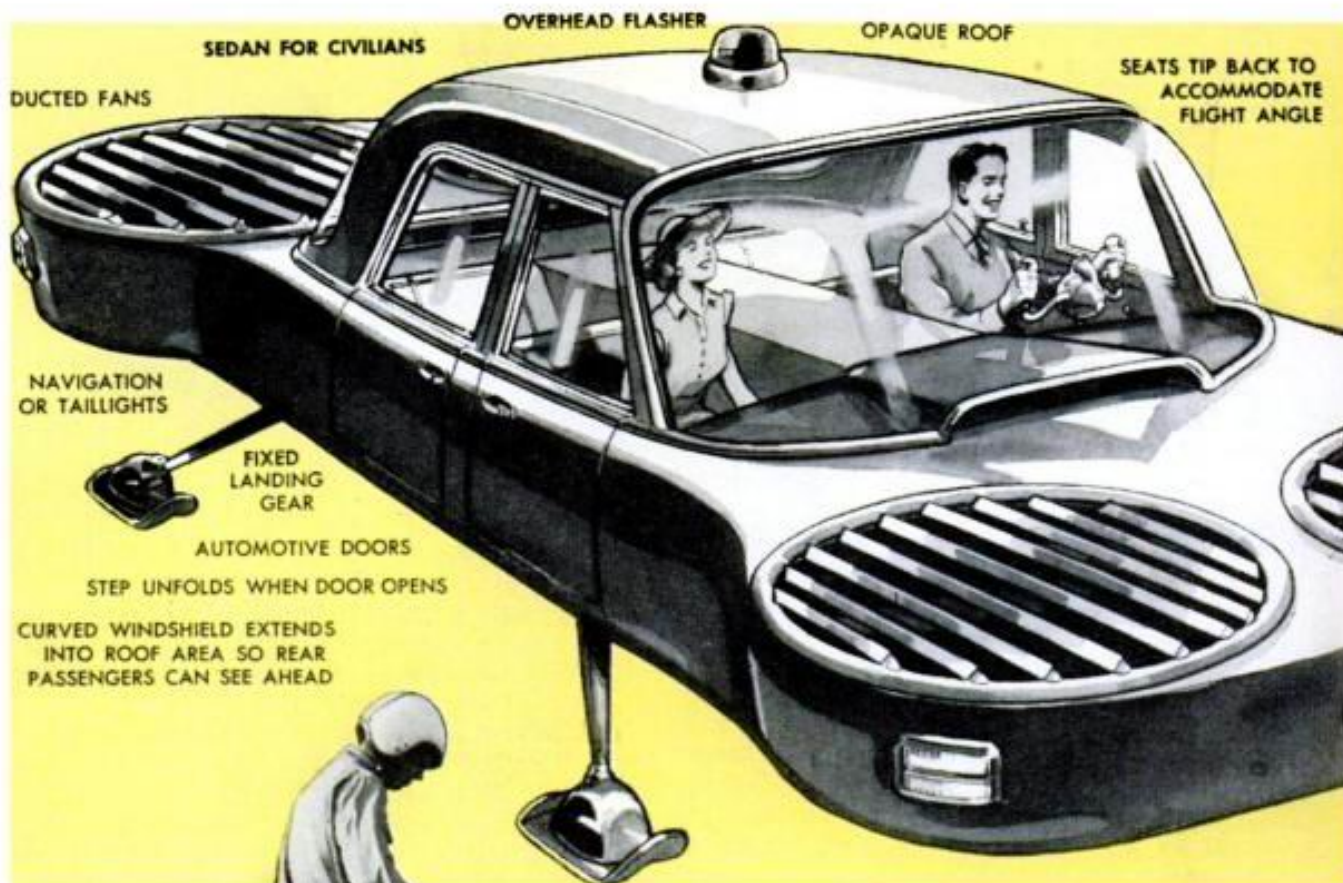
HILLER'S AERIAL SEDAN

—your flying car for 1967—page 74

Stand by for Satellite Take-Off!

Owners Report: OLDSMOBILE

HOW TO OUTSMART HOUSEBREAKERS



YOUR

By
**Thomas E.
Stimson, Jr.**

A NEW KIND of flying machine is being designed that sounds like the answer to your desires for a personal aerial vehicle.

It is almost like a flying carpet. A good name for it might be the "flying fan." It uses the principle of the ducted fan, the same idea that is used by the flying platform.

Superficially this new machine, now being developed by Hiller Helicopters, will resemble an automobile although it will rest on short stilts. You'll be able to order a four-door model, a sports job or even a light-truck configuration.

To fly it, open the door and sit down behind the wheel. That button on the instrument panel operates the starter, and there's a faint whine and hum while you get the turbines up to speed.

See those two levers? The one on the left is the climb control. Push it up and leave it there. Now we are

Principle of "flying fan" vehicles of future is same as that of flying platform, left, which gets lift from air forced through duct

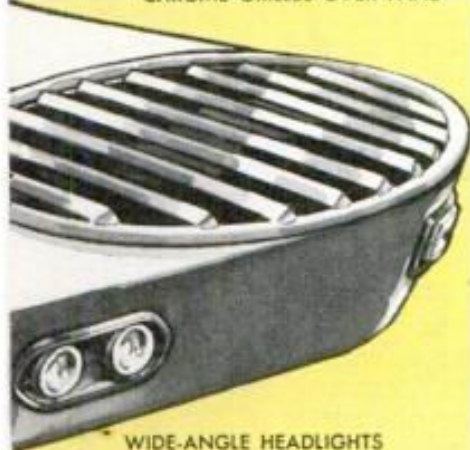


FLIGHT ANGLE



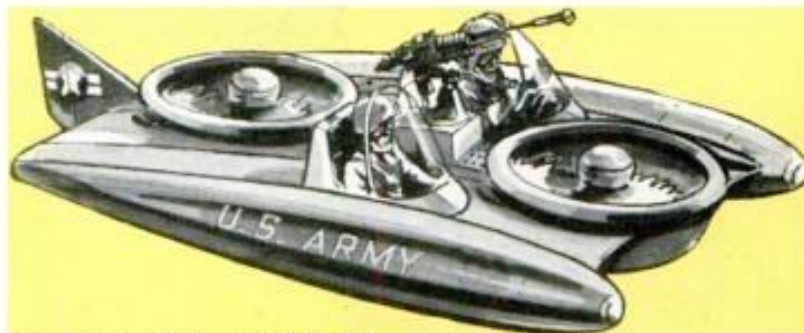
FAN-POWERED CAR WILL FLY WITH NOSE SLIGHTLY TILTED DOWNWARD

CHROME GRILLES OVER FANS

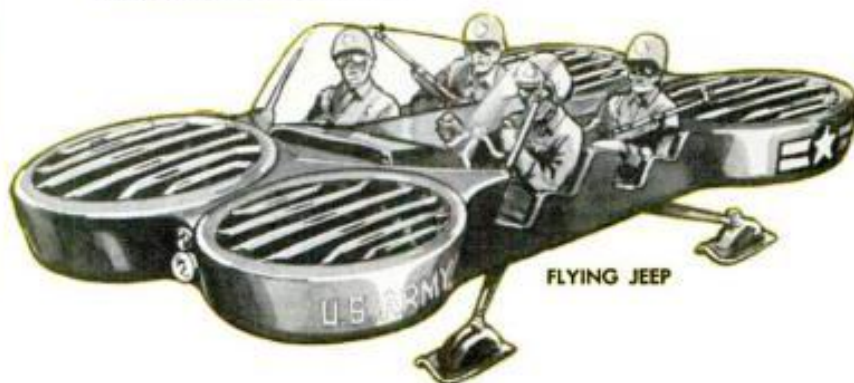


WIDE-ANGLE HEADLIGHTS

MILITARY USES



ABLE TO LAND ON ROUGH TERRAIN, ARMY VEHICLE COULD BE "RECON" CAR OR FLYING GUN PLATFORM



AERIAL SEDAN FOR 1967

rising. Easy, isn't it? There's no big thrashing rotor overhead, no churning propellers. We just ascend with no apparent effort.

We are higher than the roof-tops now, so let's head across town. Turn the wheel to the right, in the direction we want to go. Now that second lever, push it ahead. Sure our nose dropped a bit. That's what the lever's for. It took some of the power off the front fans and tilted the machine. That's the way this thing flies. Air speed is up to 50 miles per hour already. If you want to stop in mid-air, just move the lever back again.

All this sounds too easy to be true, but the designers say this description is about right. They say the fans have most of the advantages and few of the disadvantages of ordinary helicopters. The fans will be easier to fly and should cost a lot less. It's too early to quote prices or delivery dates now: A rough guess is that in about 10 years you'll be able to buy a four-place fan for the price of a good car.

How can engineers be so sure about something that hasn't been flown yet, or even built?

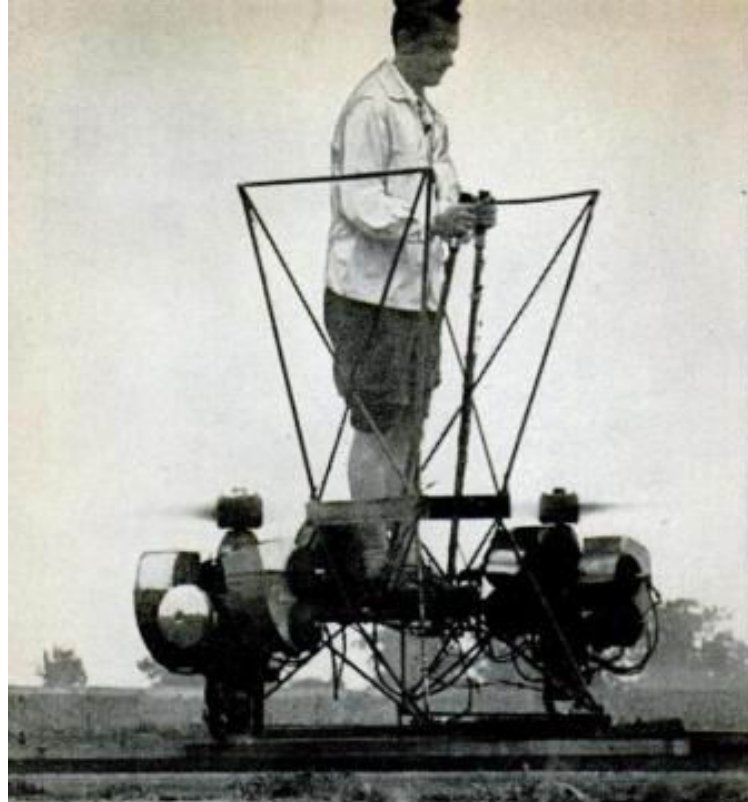
For one thing, the flying fan is nothing more than four ducted fans that are held together by a framework that supports the

engines and cabin. A ducted fan is a shroud or duct that is placed around a propeller. This duct has a wide flange or lip around its upper edge. When the propeller forces air downward through the duct, pressure above the lipped surface is reduced. An extraordinary amount of lift is obtained as compared to an unducted helicopter rotor.

The Hiller flying platform was the first practical vehicle to use the ducted-fan principle, and the platform has made scores of flights. Some of the early bugs have been worked out of it. A new and advanced model is under construction.

A multifan vehicle is an obvious improvement over a simple flying platform. The platform is maneuvered by the body movements of its operator. He leans in the direction he wants to travel. He depends on his sense of balance, something that could be unreliable at night or in a dense fog.

With four fans, controllability is materially increased. The vehicle is maneuvered by varying the revolutions per minute of the front or rear fans. With twin power plants, possibly automotive gas turbines of the type that has been demonstrated by Chrysler, there's little chance of a complete power failure. If one turbine fails, the other

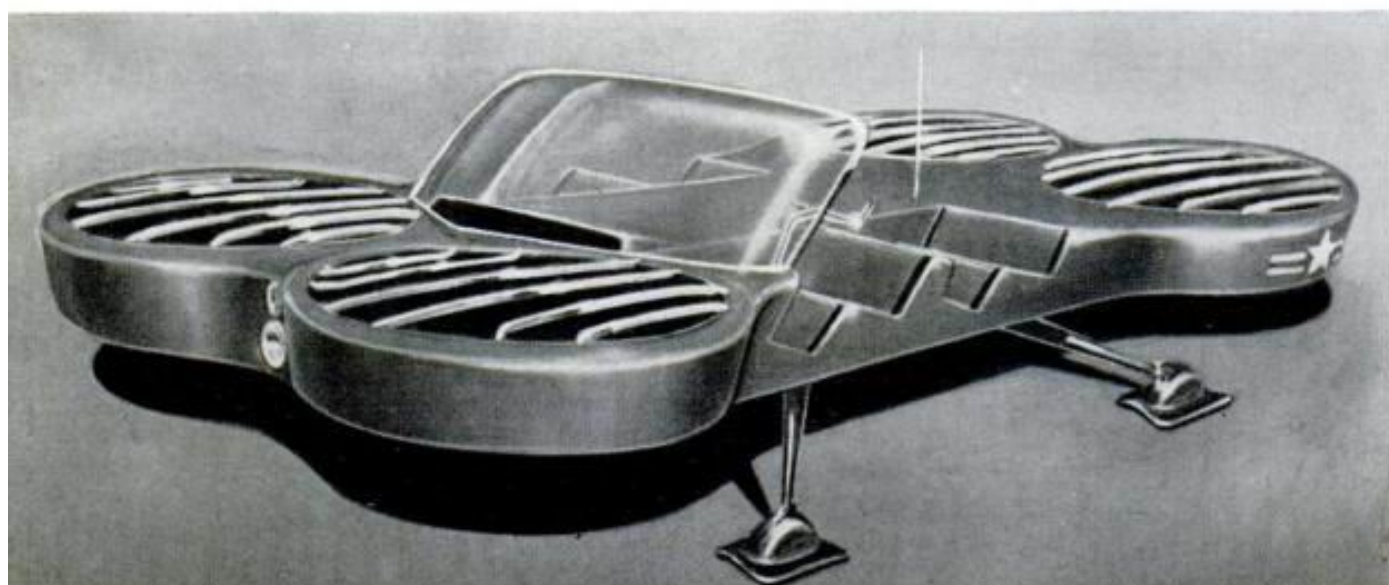


Original flying platform was this device which had two propellers to force air downward. This in turn led to concept of the shrouded or ducted platform



Close-up of first flying platform, above, shows it was something like two small helicopters. Putting duct around blades proved to be much more efficient

Hiller proposal for a "flying Jeep," below, would have four seats and cruising speed of 60 miles per hour



one would keep the vehicle sufficiently stable to permit an easy emergency landing.

Probably the first flying fan will be in the form of an aerial Jeep, an aircraft in which the Army is greatly interested. Hiller Helicopters has submitted a proposal for a four-fan Jeep. Basic engineering studies have been completed. Performance and costs have been closely estimated.

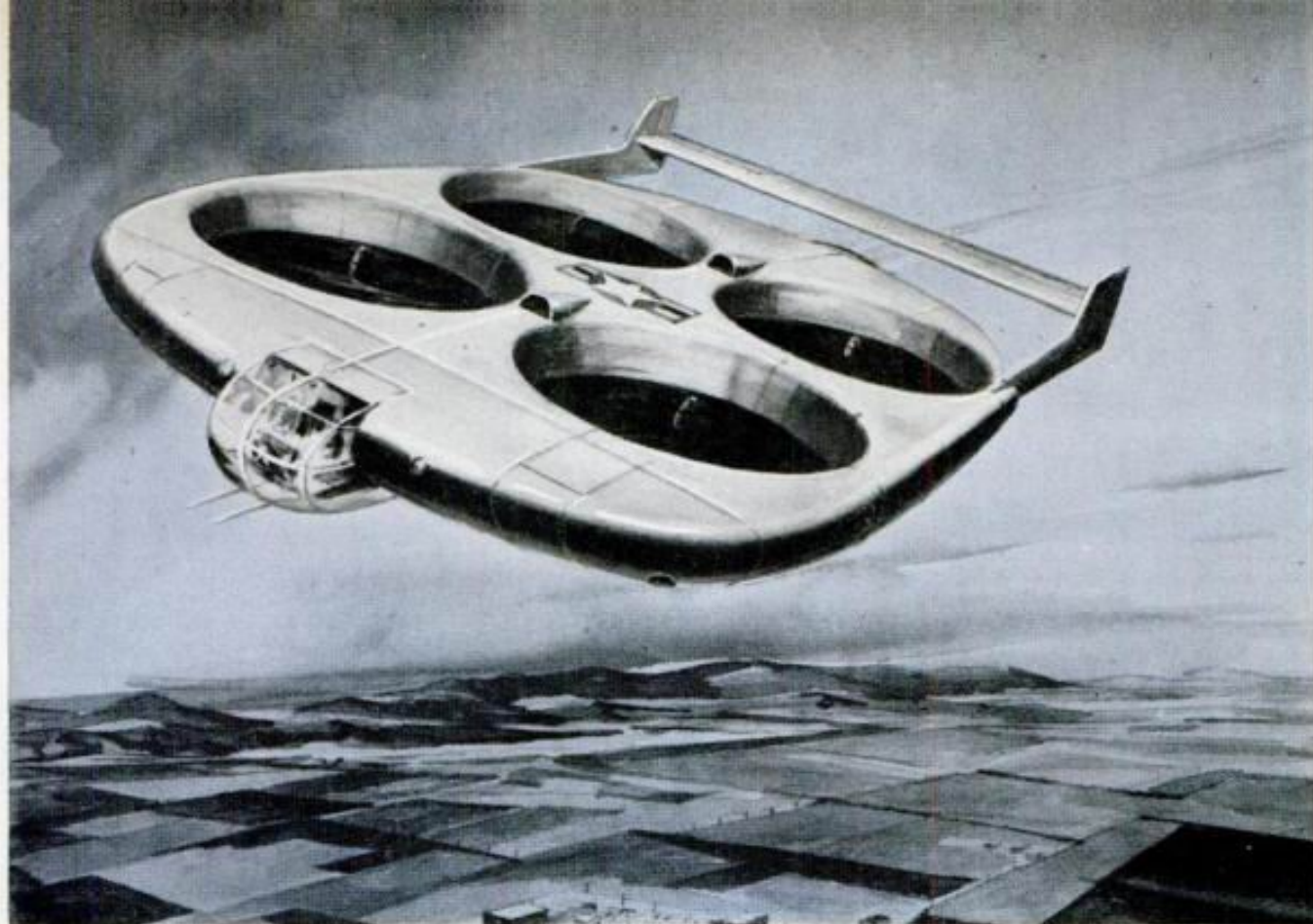
This Jeep-of-the-air would be capable of every job that an ordinary Jeep can do, with the advantage that it could travel across country with no need for roads. It would be able to land and take off from fairly steep hillsides. It could carry men and supplies, be used as an ambulance, or serve as a recon vehicle or even a flying gun platform.

Advantages Over a Copter

For this kind of service the flying fan has several major advantages over an ordinary helicopter. It can operate close to buildings or other obstructions. A helicopter taking off from alongside a building gets a rebound of air from the building that makes it very hard to control. And the flying fan can be operated around people in safety, with no chance that someone might accidentally walk into the whirling overhead rotor.

The Hiller engineers expect that eventually the ducted fan will become the basis for a whole family of special-purpose aircraft, the largest of which would be a "flying crane" that could lift enormous loads over short distances. The ducted fans look better for this job than do the huge helicopters that have been tried out in the past.

One of the Hiller proposals is a flying crane that would consist of four large fans, each about 15 feet in diameter. They would be bolted together in the form of a rough square to provide great lifting capacity. The gas-turbine power plant would be located in the center, with a bubblelike control cabin placed in front. Standing off the ground



Four large fans in a streamlined airfoil could be combined with jet engines for swift forward propulsion

on tall, stiltlike legs, there would be plenty of room below the crane for moving into place below it a heavy tractor, large truck or loaded cargo box.

Basically the ducted fan is not a very fast vehicle. In its present stage of development it is good for approximately 50 miles per hour. One hundred miles per hour may become possible in the future.

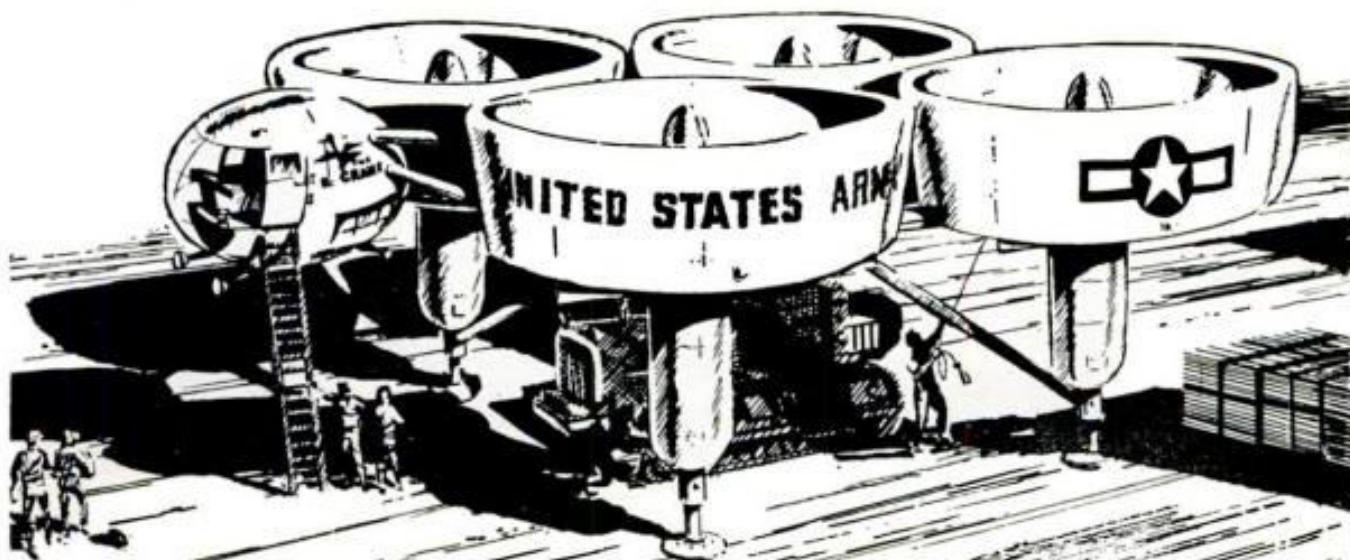
Possible Airborne Sentries

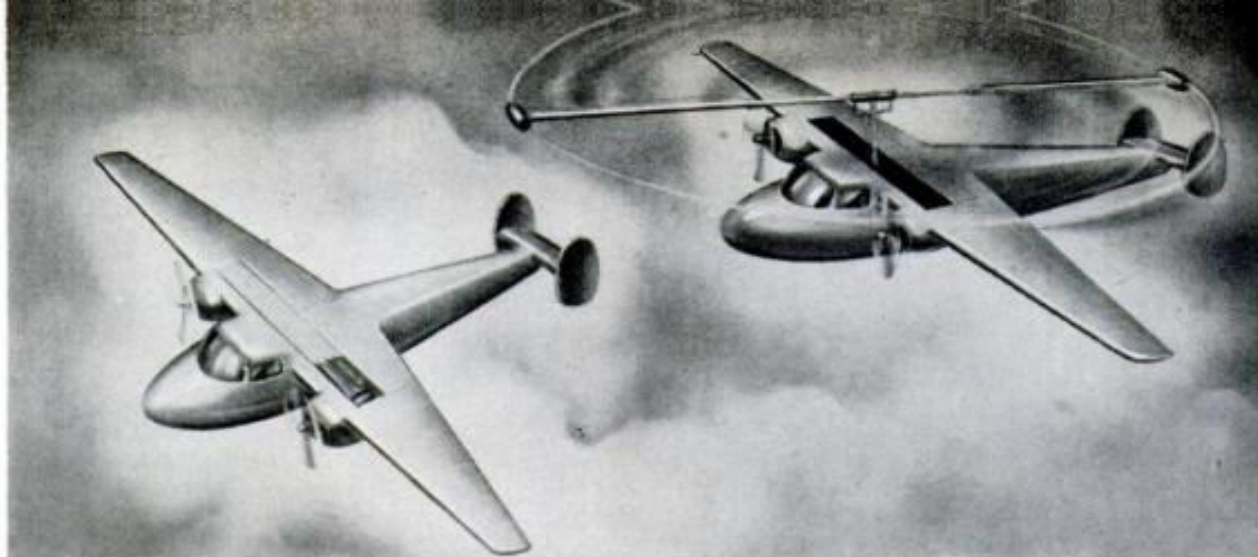
There's a chance that this kind of platform could be used for aerial sentry duty to guard national boundaries against intruding bombers. One suggestion is to install early warning radar equipment on one

big platform, with the second platform of the team loaded to capacity with guided missiles. Hovering at medium altitudes, such a team would be able to detect and destroy hostile aircraft while they were still a long way off.

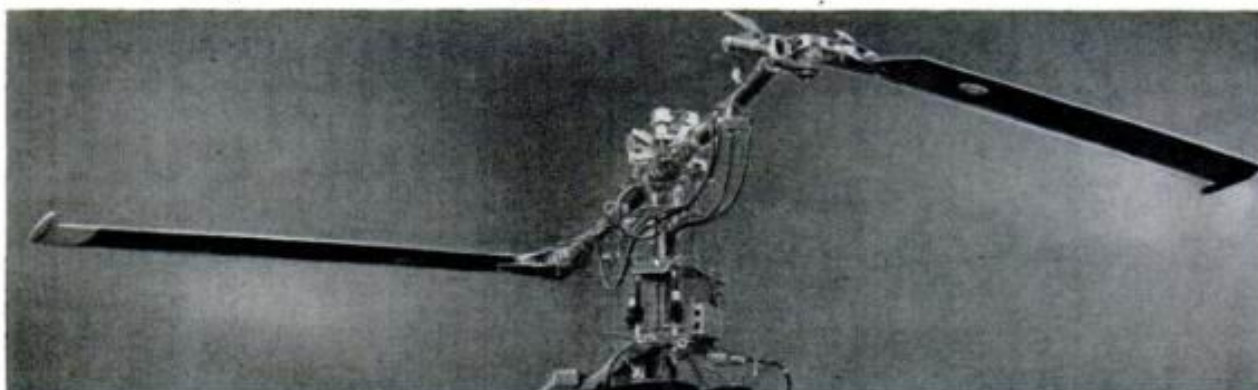
The ducted fan is not the only new idea that is being investigated for vertical-rising aircraft. One study Hiller has made is for a combination helicopter and airplane. This craft looks like an ordinary plane but has a large rotor overhead. The craft would use its rotor for taking off straight up, then as it began to use its main power plants to achieve forward speed, the rotor blades would fold and retract into the wing.

"Flying crane," below, has been proposed to U. S. Army for lifting trucks and tractors across rough terrain





Retractable rotor systems, above, are being studied as aid for vertical landing of conventional aircraft

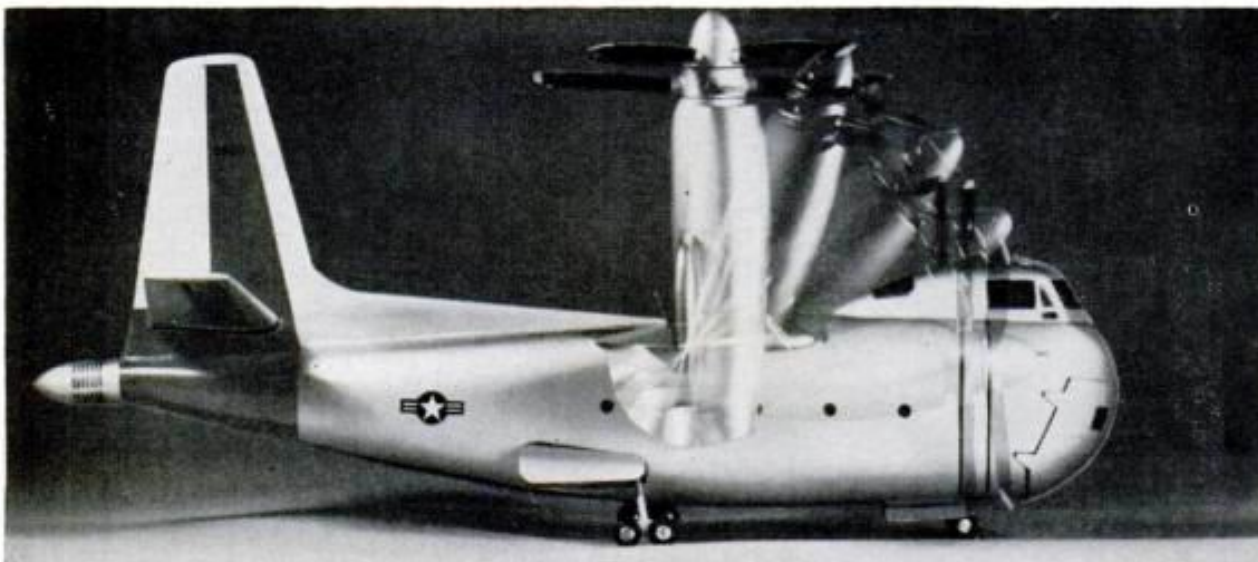


Folding rotor assembly being tested in the Hiller factory. Rotor-tip pods would hold ramjet engines

Now under construction at the Hiller factory in Palo Alto, Calif., is a transport plane with a tilting wing. For vertical take-offs the wing is rotated to a vertical position so that its twin turboprop power plants exert their thrust straight down. After take-off the pilot rotates the wing toward its normal angle, reducing the rate of climb and at the same time acquiring forward speed. Eventually, with its wing locked in the standard horizontal position, the plane flies just like any other airplane.

Vertical take-offs are not always necessary, and one of the advantages of the tilt-wing transport is that it can take off or land at any angle desired, depending on the length of the landing strip and the load that the plane is carrying. With a long runway, the plane would take off just like any other airplane. With a very short runway, the pilot would tilt the wing to get just the amount of lift he needed, and then take off in the short distance that was available to him. ★ ★ ★

Now under construction is a tilting-wing transport. For take-off, wing will turn to vertical position



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**Jet "Donkeys" for
The Big Jets—
Page 72**



In This Issue

**WHAT'S IT LIKE TO
LIVE IN A VACUUM?**

What We've Learned From the IGY

BUILD AN OUTRIGGER SAILBOAT



Jet "Donkeys" for the Jets

By Richard F. Dempewolff

BIG JET FIGHTERS and bombers are running out of runway. Wafer-thin delta wings, built for supersonic speeds in the thin air along the rim of outer space, must fight down the runway to build the speed it takes to get them airborne. The 150,000-pound B-58 Hustler, using all the thrust she can muster (64,000 pounds from four jets) needs plenty of run. Newer high-flying ships will need more. Even military fields don't all have two-mile runways, and geography doesn't always provide flat terrain in places where airfields are needed.

One solution, dreamed up by All American Engineering in Wilmington, Del., is a jet "donkey plane" that will hook on to the belly of a bomber and provide it with a "kick in the pants." Boosting the ship down the runway and into the air, in much less distance due to 10,000 to 12,000 pounds of additional thrust and the extra lift provided by its own wings, the donkey will ride with the bomber until the mother ship is at safe speed and altitude. Then it will detach and circle back to base. Robert B. Cotton, vice-president of All American, sees no reason why small fleets of pusher jets couldn't launch whole squadrons of supersonic high-fliers with speedy dis-

patch. "So far," he says, "it's just a drawing-board idea, but the concept is a practical one, stemming from actual experiments with our big rubber-tired, four-jet cars."

On test tracks at Georgetown, Del., and at the Naval Air Station in Lakehurst, N. J., the "hot rods" Cotton refers to have been roaring at 200 miles per hour for more than a year. "The Navy wanted to develop and test new, more powerful arresting gear that would stand up under the walloping impact of the newer, bigger carrier jets," he explains. "To do the job without wrecking a lot of expensive airplanes every time an experimental arresting gear failed, we were given the job of developing a big car, powered by turbojet aircraft engines. This vehicle would shove a dead load (equal to the weight of a big carrier plane) down a track at 200 knots, simulating the landing speed of a carrier jet. The car would brake to a stop while the load, on wheels, rolled free to snag the gear."

Today you can see the rocketing red monsters doing just that. The "cars" look like gigantic squatting bugs—if you can picture a bug 20 feet square. A typical one houses four surplus Allison J33 turbojets with a total thrust of 28,000 pounds. These



As soon as the big plane gathers a safe speed and altitude, the jet "donkey" breaks away and flies back to the field for another launching

are rigged in a chassis of steel tubing and cloaked in aluminum streamlining to give the vehicle the appearance of the center section of a flying wing. It rides on four aircraft wheels with rubber tires, and requires no driver to guide it. In assembling the equipment for a run, the car is secured, by means of steel "slippers," to a guide rail running down the center of the track. Riding ahead of the jet pusher is the dead load—a wheeled platform of steel plates and girders weighing from 10,000 to 60,000 pounds. After fueling, the jet pusher is hitched to a hold-back device, and everyone heads for cover.

Halfway down the track a crew in a blockhouse checks the gauges on a remote-control panel. At the "track clear" signal, switches are thrown. With booming roars, the jets ignite. Inside the blockhouse, dials come alive. The monitor scans tail-pipe temperatures, r.p.m., fuel flow. When everything checks out, the remote control switch is thrown, dropping the hold-back hook. Connections pop free as the car moves away, functioning now on fuel and electrical circuits contained in its own rumbling core.

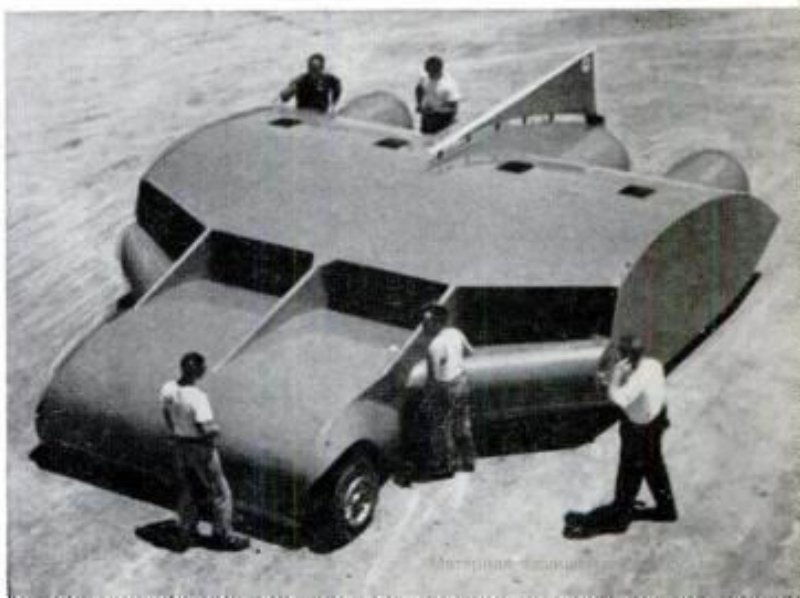
Jet roar rising to a scream, the pusher thunders down the track, jamming its load ahead of it at a 200-knot clip. Near the end of the course, the car trips a trigger, automatically cutting the engines. The flange on the rail widens. With a screech of hot steel and a puff of blue smoke, the "slippers" jam against the flaring rail, jerking the car to a halt. The dead load hurtles on alone, down the concrete strip until the "tail hook" with



which it is equipped snags a test-arresting gear cable that is stretched across the track. A ribbon of dust whips into the air as a 25-ton behemoth twangs the cable, stretching it out against water-squeezing pistons that are designed to absorb the energy and stop the load within 150 feet.

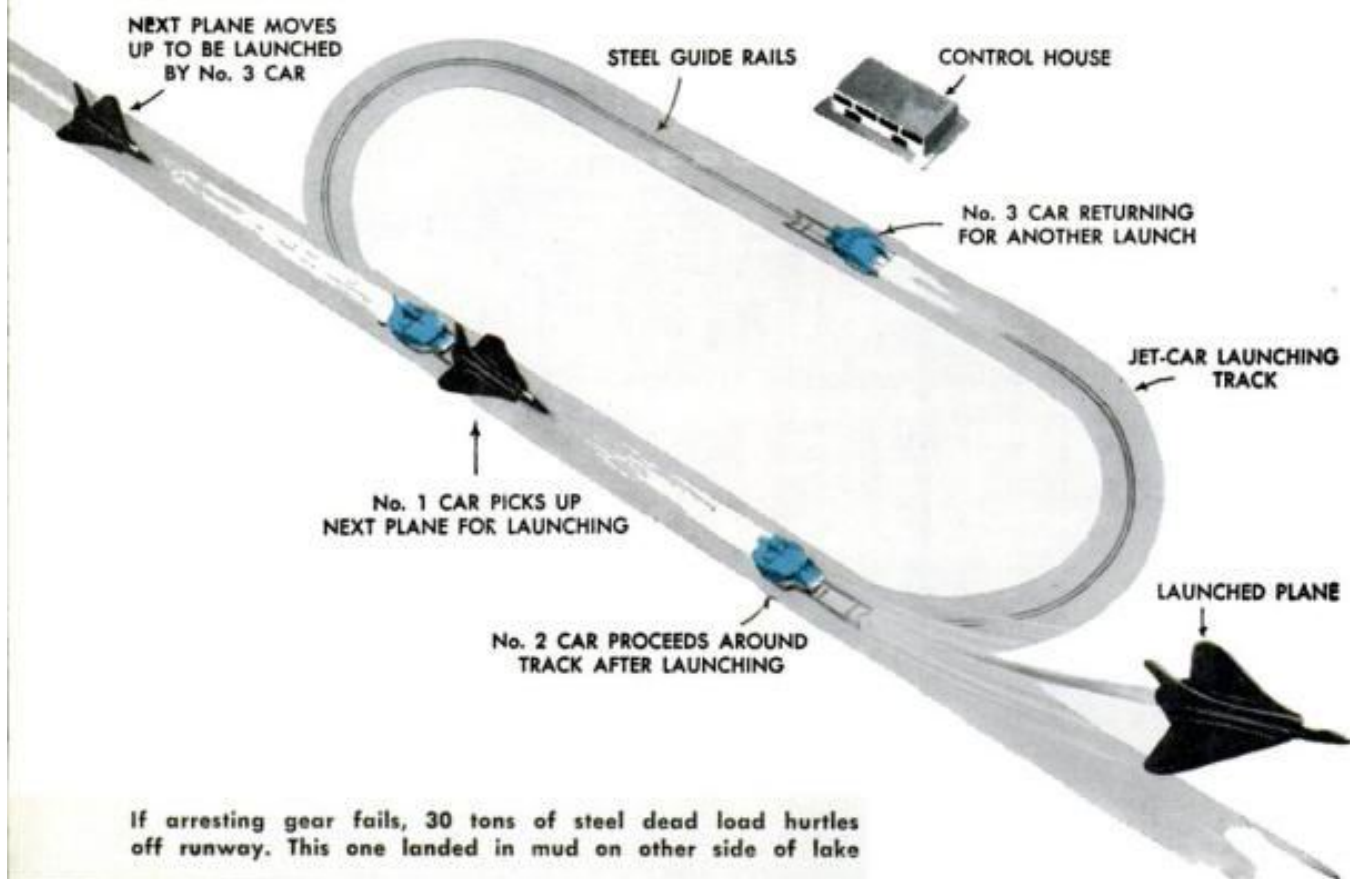
What happens if the cable lets go? That's the reason for the blockhouse. At All American's test track in Georgetown, the strip ends near a lake. Many a runaway dead load has plunged into the water. One

Capable of ramming dead load at 200 knots, this four-engine jet car may launch bombers from very short runways





At 200 knots, slippers behind the experimental test car jam against flare in rail, stopping car as load rolls on



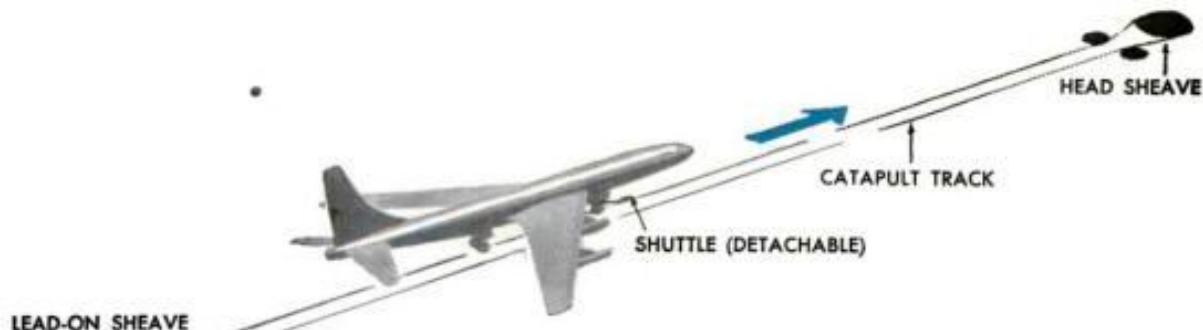
If arresting gear fails, 30 tons of steel dead load hurtles off runway. This one landed in mud on other side of lake



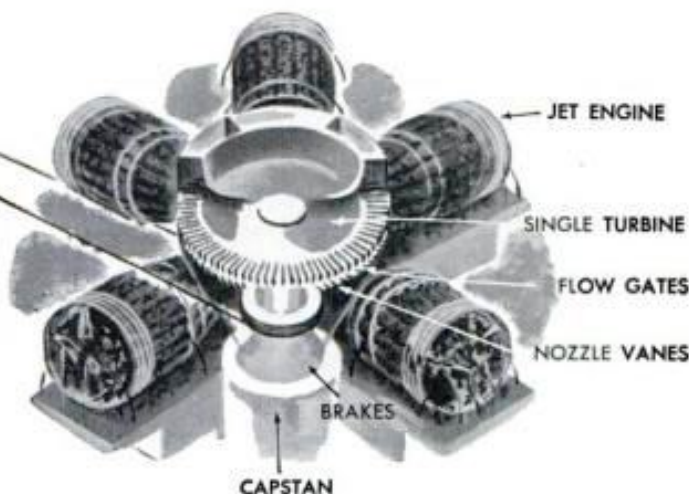
went clear across the lake and half buried itself in the mud on the other side. "No one is allowed anywhere near the strip during a run," explains one engineer. "A failure on one side of a cable could send that 25 tons of steel on wheels pinwheeling wildly in almost any direction."

On one occasion a car threw a turbine blade, filling the air with shrapnel. Since then the hot rods have acquired a shell of armor plate.

The speed and power developed by the hot rods, plus their economy (they are made largely of surplus engines and parts) made them obvious candidates for a



Simplified drawing of six-jet catapult engine, which powers launching cable to which jet bombers and tankers are attached for high-speed take-offs



host of other high-powered applications.

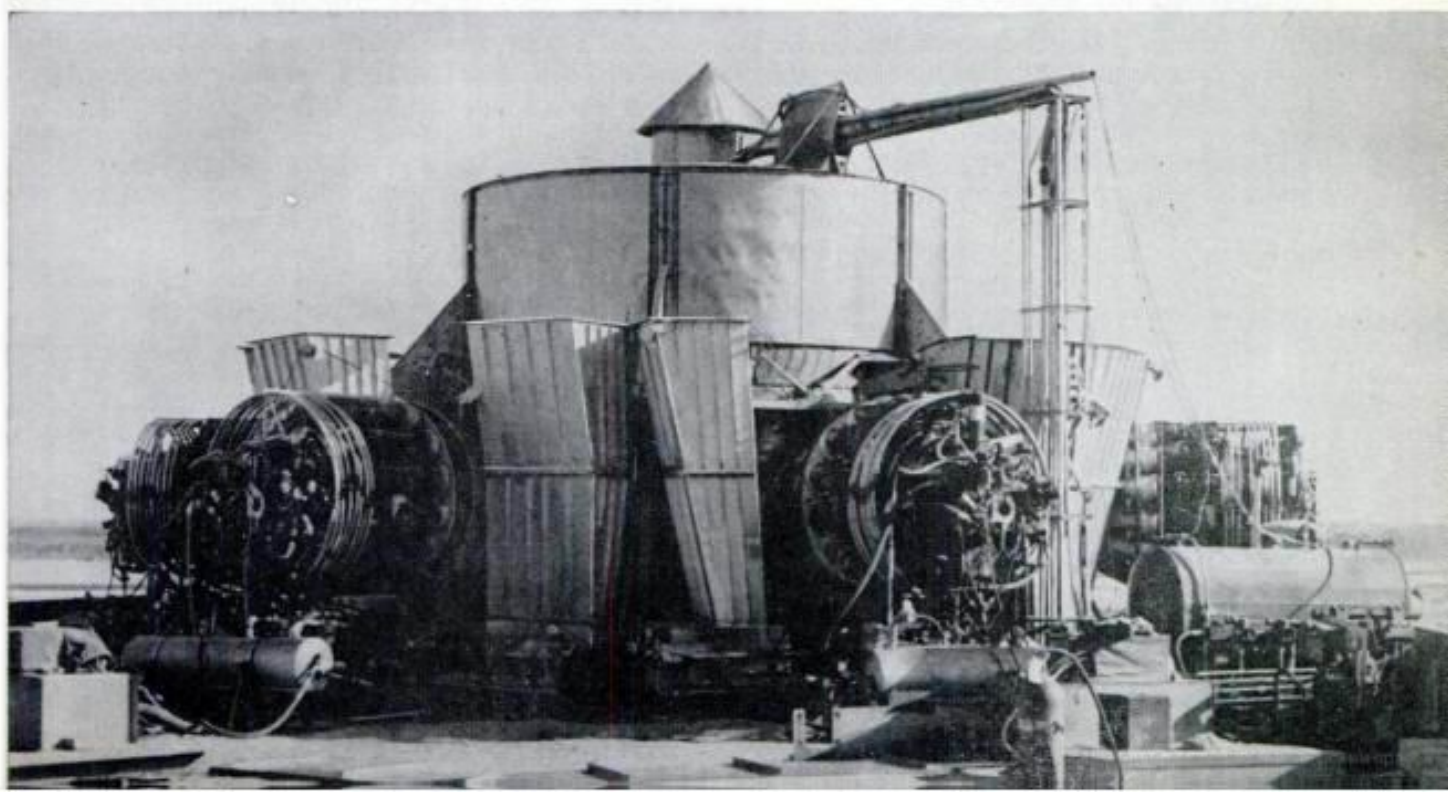
The car has excited so much interest as a vehicle for solving launching and arresting problems for tomorrow's planes that the Navy is now completing a \$35,500,000 launching-and-recovery laboratory at Lakehurst, where jet red hot rods will be among the star performers. Five jet-car tracks, varying from one to two miles long, spread across the fields like ribs in a fan. These will be used for testing. Beside them lies a two-mile runway bordered by subterranean chambers housing catapults and arresting equipment for "live runs."

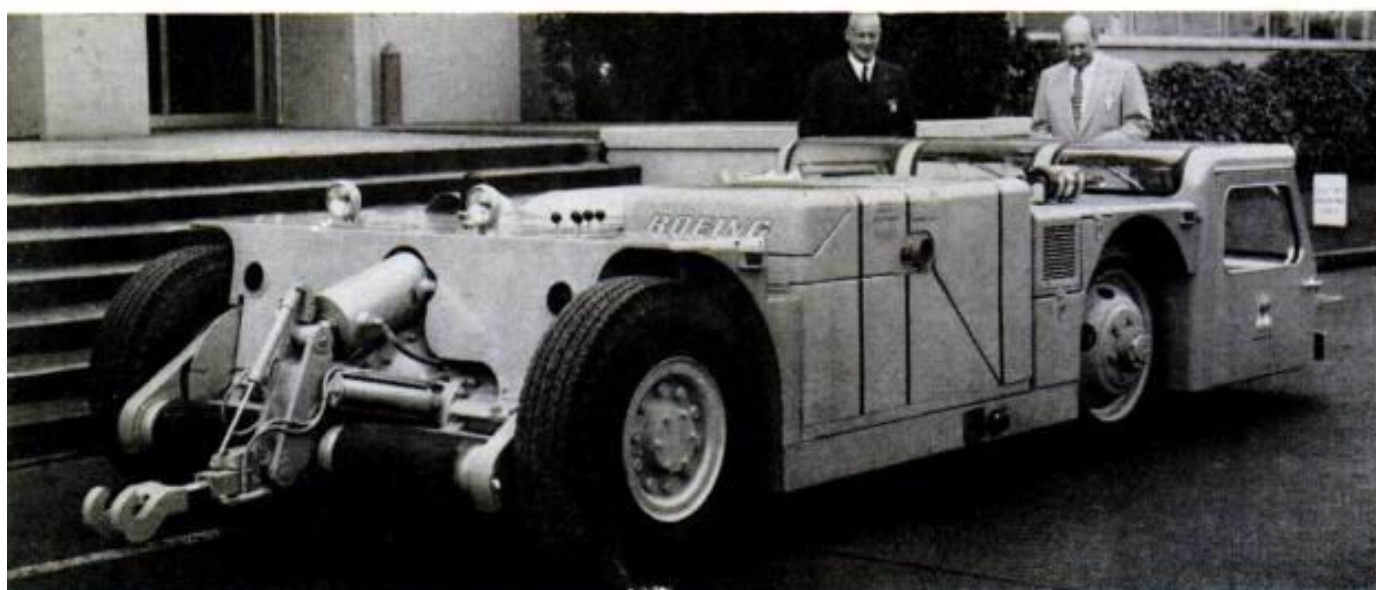
Beyond this strip is a mile-long oval known as the Short Field Installation. On it, a special fleet of jet cars will be used in a development program for launching big

planes. The cars, riding a continuous course, will shove planes ahead of them, rapidly accelerating them to flying speed. When the plane is airborne, the car will continue around the course to launch another. According to Navy engineer Joseph Terry, the cars could provide the answer to a rapid-cycling shore-based launching facility. Two or more cars would operate on the track simultaneously. These hot rods would probably be lower-slung, with

(Continued to page 258)

A close-up view of launcher. Its 50,000 horsepower are transmitted to cable without gears or clutches





Rollers on Tug Move Big Jet Planes Around Airport

Big jet aircraft are now maneuvered on the ground by a trucklike vehicle that fits underneath the front of the plane. The Turbo-Tug is coupled to the plane, and the

drive rollers at the rear of the tug are brought into contact with the craft's tires. Traction is provided by the plane's weight riding on its own landing gear.

Foam-Plastic Mattress Tailored to Fit Wagons

Tailored to fit neatly around fender wells, a foam plastic pad gives complete comfort to children in the rear of station wagons. It is covered with washable plastic fabric and is about half as heavy as conventional padding. One version of the mattress is made in two sections so it can be used double when the rear seat is occupied.

Nylon-Rubber "Muscle" Moves Paralyzed Hands

Use of paralyzed hands is made possible by an artificial "muscle" made of nylon fiber woven around a length of rubber tubing. A metal harness fits over the fingers, which are controlled by the flow of compressed carbon dioxide gas in and out of the tube. A simple switch operates the muscle.



SHOULD YOU BUY A FOREIGN CAR?

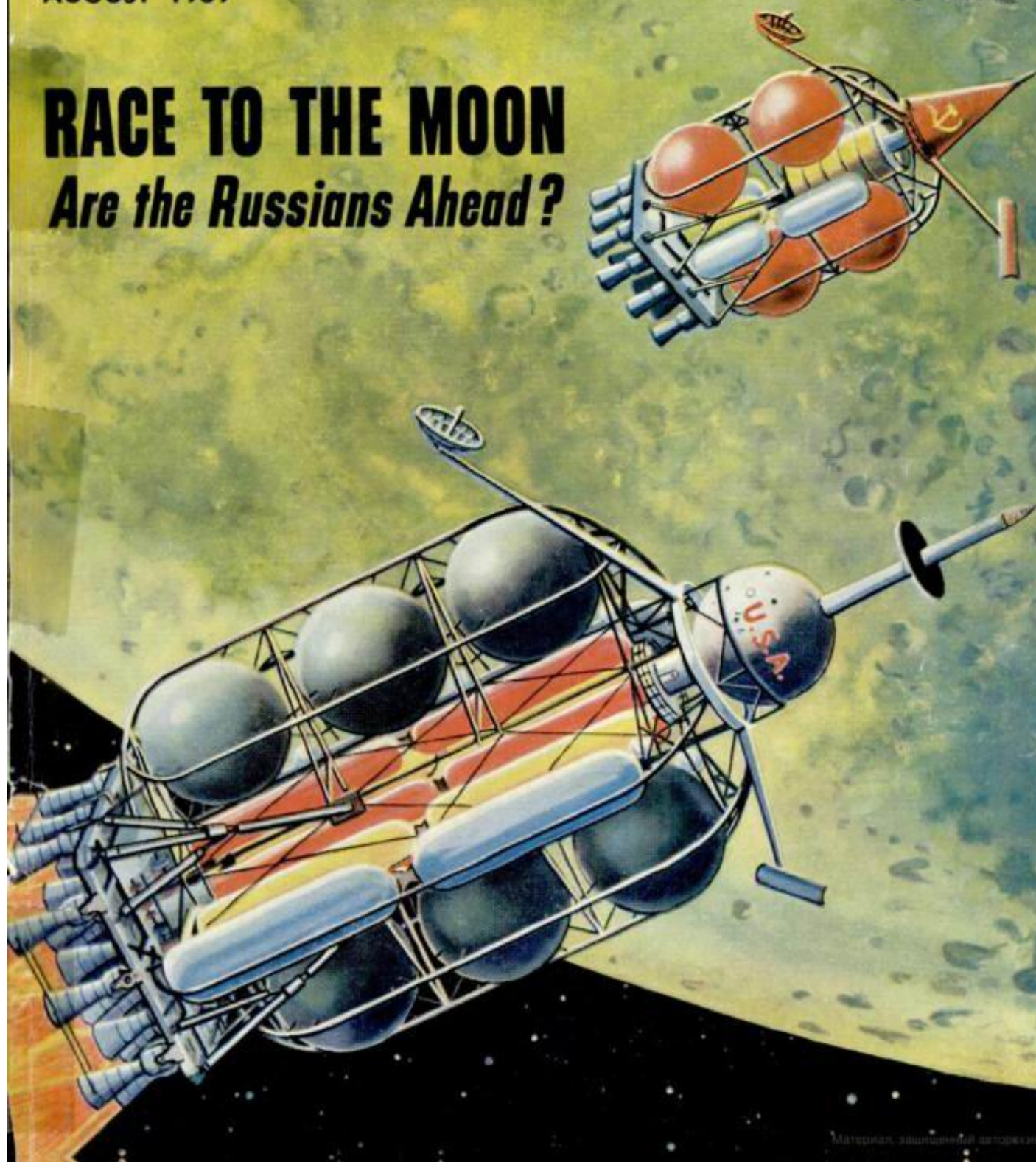
POPULAR MECHANICS

WRITTEN SO YOU CAN UNDERSTAND IT

AUGUST 1959

35 CENTS

RACE TO THE MOON
Are the Russians Ahead?



RACE TO

By Dr. Dan Q. Posin

PROFESSOR OF PHYSICS, DE PAUL UNIVERSITY
SCIENTIFIC CONSULTANT AND ADVISOR,
COLUMBIA BROADCASTING SYSTEM



SOVTOLO

THE RACE is on. Someday soon we will hear an announcement that a spaceship, bearing men, is on its way to the moon.

How soon? Will the men be Americans? Or will they be Russians?

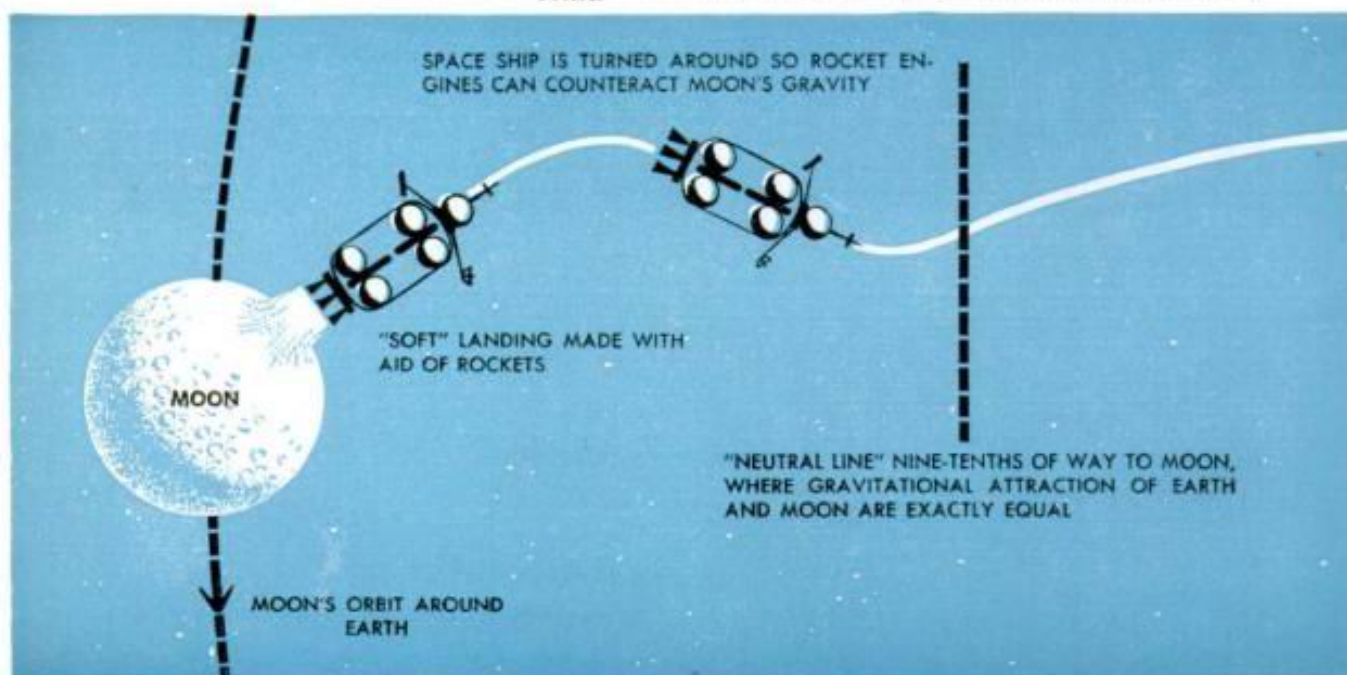
But why should men—Russian or American—go to the moon? Is there a purpose to this expensive and dangerous project?

Men will go to the moon simply because the Age of Space has come. There is no turning our backs on progress, on science, on the universe. The competition with the Russians, of course, whips us onward. But the moon itself has little to do with military needs. We're on our way—we hope—for prestige, because of the spirit of adventure, because the moon is "there" and we can get to it. Earthlings—Americans, Russians, and all other earthlings—have a rendezvous with the universe. The time has come. We are on our way.

Does it really matter who is first to the moon?

Some men, peering out into the majesty

RUSSIAN photo shows pressure suit developed to protect men who will be sent beyond the atmosphere. Below, author's conception of first trip to the moon



THE MOON

of space from this tiny planet, are tempted to look upon the universe as a further battleground for the tensions we suffer on earth. Others view the exploration of space as a challenging adventure, still others as an opportunity for tremendous strides in scientific research. Whatever their motives may be, let us listen to the protagonists in this race to the moon.

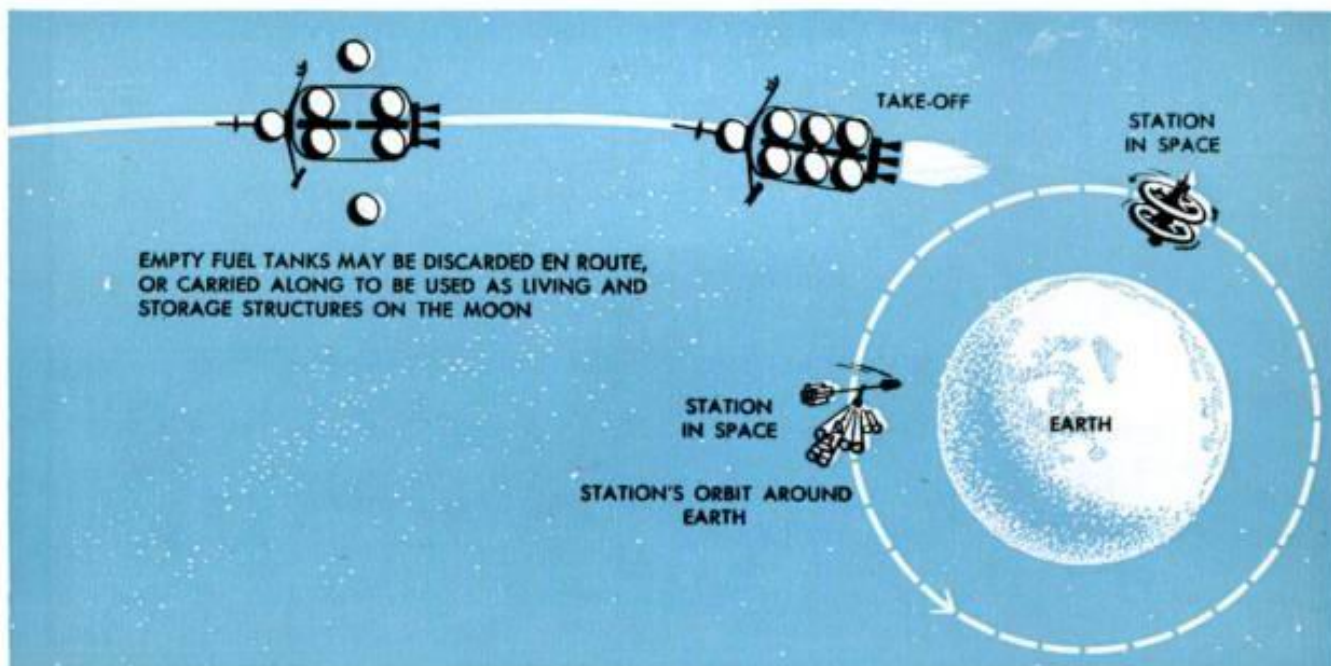
- Here is A. Dorodnitsin, member of the U.S.S.R. Academy of Sciences: "The creation of man's first artificial planet demonstrates that Soviet rocket engineering is well on the way to conquering the cosmos . . ."

- And here is A. Ilyushin, member of the U.S.S.R. Academy of Sciences: "The attainment of success by the rocket whose 3244-pound last stage is now in orbit around the sun, proves that Soviet science and technology have the necessary prerequisites for the next step ahead . . ."

- And Professor V. Dobronravov, Doctor of Science in Physics and Mathematics: "Some of the routes for a flight to the moon have already been worked out . . ."

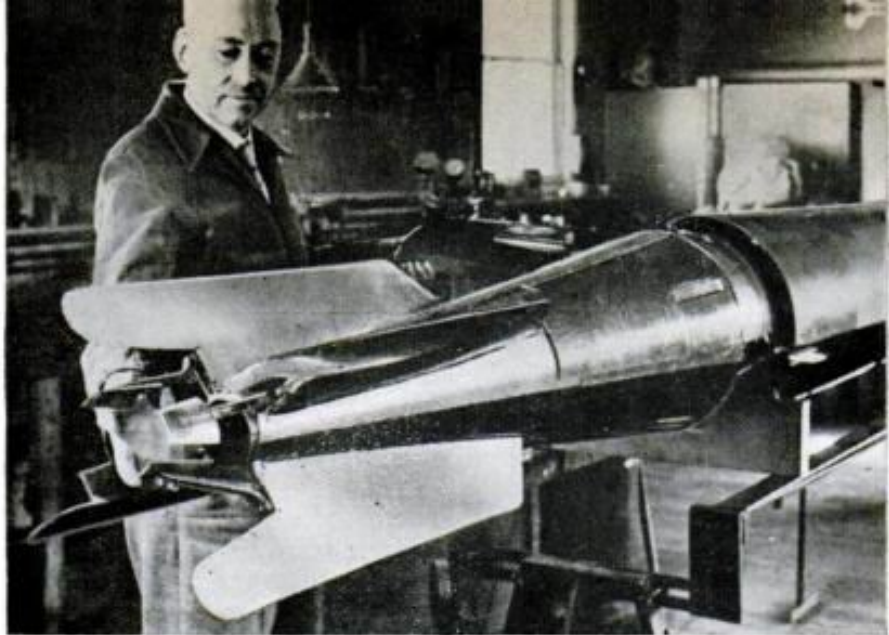
Are these statements simply propaganda? Here is Wernher von Braun, the U. S. expert, testifying in January before a Senate committee: "It will

AMERICAN spaceman may wear this type of suit, which was recently tested in Litton Industries' high-vacuum lab where space conditions can be simulated





RUSSIAN father of space travel was the self-educated Tsiolkovsky



AMERICAN pioneer was Dr. Robert H. Goddard, who followed Tsiolkovsky by a quarter century. He predicted shot of multistage rocket to moon

take the United States five years to overtake Russia in the intercontinental ballistic missile field even if the United States would go all out . . . Russia's *Mechta* (fired past the moon into orbit around the sun) proves again that the Soviets have more powerful rockets than the U.S., and that the guidance was very accurate . . ."

In order to project developments into the near future—to judge the race to the moon—it is worthwhile to take a brief look at the past. Two great figures stand out in the history of rocketry, one Russian, the other American.

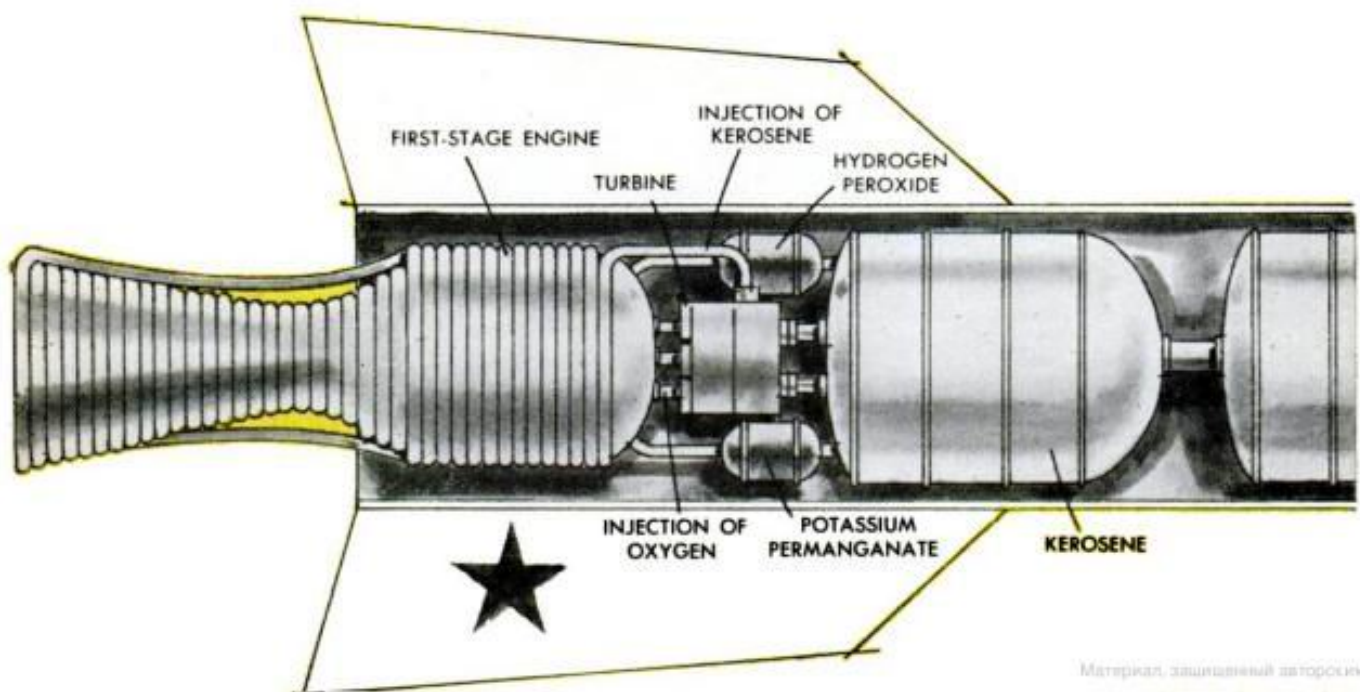
Tsiolkovsky—Russia's Pioneer

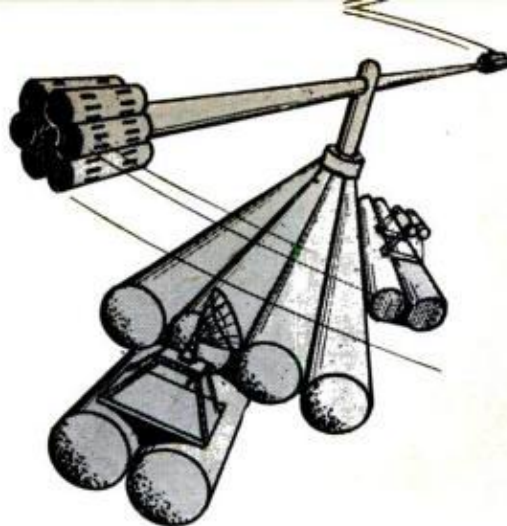
Russian spacemen revere Konstantin Eduardovich Tsiolkovsky. Born in 1857, he was a self-educated schoolteacher who, 80 years ago, started to think seriously and scientifically about man into space. He was shy and deaf, yet he set himself the cosmic task of using the laws of gravitation and planetary motion of the great Isaac Newton

as a springboard by which walking creatures of the planet Earth could soar into the heavens.

He succeeded. He demonstrated that the rocket was the only possible engine for space travel, and he obtained mathematically the speed which the exhaust gases would have to attain to shoot the rocket away from earth. He also concluded that the fuel should be liquid, and wrote this in 1898, when men had not even flown in airplanes. Thanks to Tsiolkovsky, Russia got in on the ground floor of rocketry and space travel. When the Battle of Stalingrad came, the Russians were ready with a blazing rocket barrage.

The United States had its bold man, too. He also was a teacher, a professor of physics. However, he had a strike against him: He was born a quarter of a century after Tsiolkovsky. Nevertheless, Robert Hutchings Goddard took mighty strides in both theoretical and experimental rocketry. Goddard predicted by theory that a multistage rocket weighing a mere 20,000 pounds





RUSSIAN conception of space station, above, has long arm which would whirl to produce sensation of gravity

AMERICAN conception, above right, consists of double wheel. Entire structure revolves to create "gravity"

RUSSIAN moonship may be smaller than American→

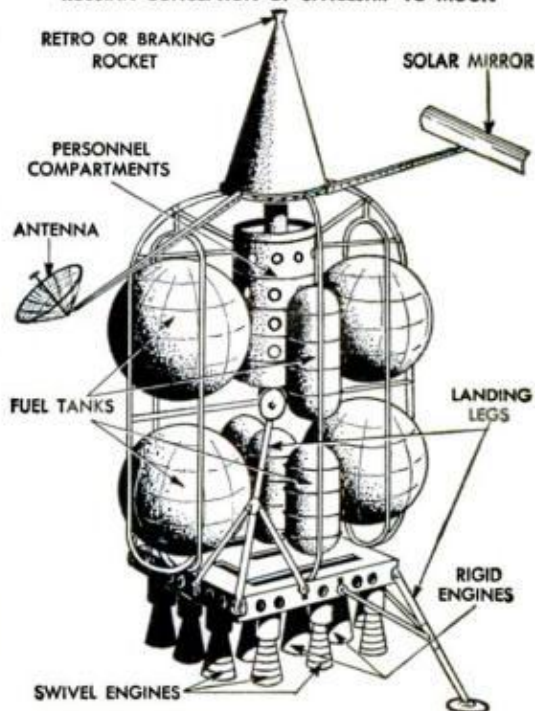
could land a small device on the moon. Newspapers ridiculed him for believing that a rocket could propel itself through a vacuum. Goddard, shy like Tsiolkovsky, drew within himself, but continued his work. In 1926 he made his first flight tests, but by 1929 he was badgered so much because of the noise of his rockets that he sought sanctuary in the deserts of New Mexico. There, under a blazing sun in 1935, Bob Goddard's rocket climbed 7500 feet into the sky. Across the United States, little groups of men began to gather with an out-of-this-world look in their eyes. They talked of a trip to the moon...

Age of Sputniks

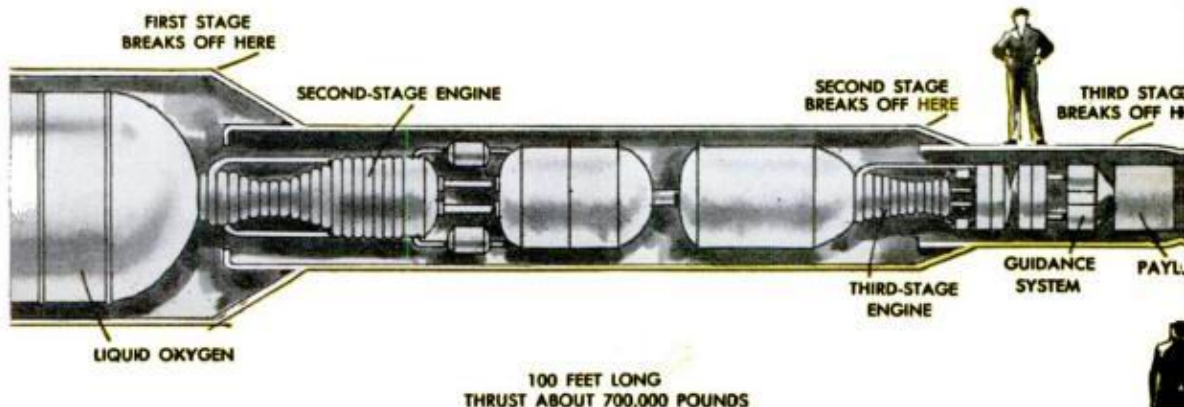
Then, suddenly, came the Sputniks, the first in October, 1957. Russia: 184 pounds into orbit. Russia: 1110 pounds, with the first live traveler. Russia: 2925 pounds.

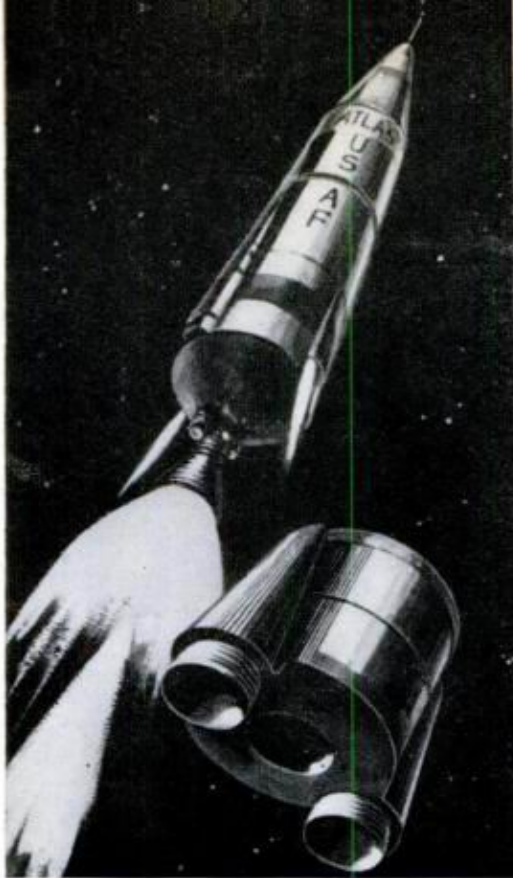


RUSSIAN CONCEPTION OF SPACESHIP TO MOON



POSSIBLE BASIC HIGH-THRUST RUSSIAN ROCKET





AMERICAN Atlas, shown during booster separation, may be "workhorse" for carrying equipment into orbit

But the first seven men already have been selected amid much fanfare, and the man-carrying space capsule to lift the first man into orbit is now under construction. The target year is 1961.

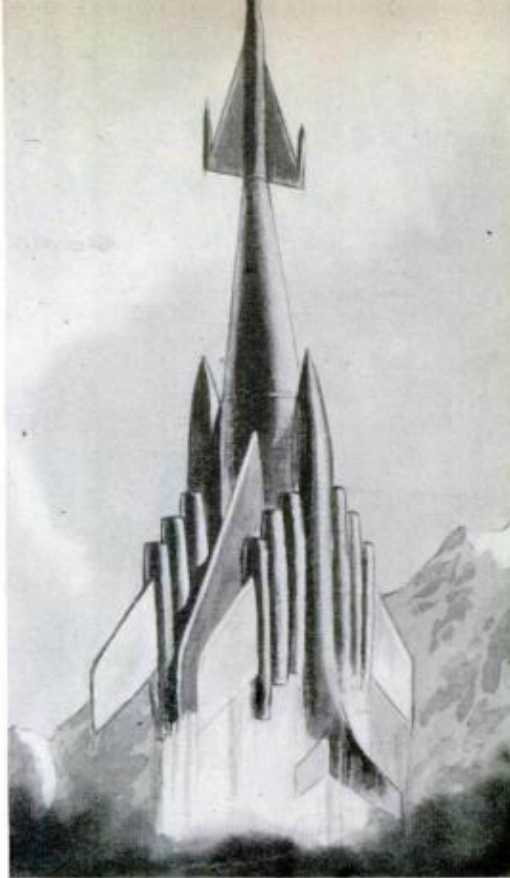
Lob Into Space

In addition, the United States is preparing a kind of lob into space—a large airplane releasing a piloted smaller one (the X-15) which will zoom 100 miles up, then descend by skimming in and out of the atmosphere. This project and many others are considered necessary probings before the journey to the moon can be undertaken by American astronauts.

Will the Russians make such probings? Or will they boldly declare: "To the moon! Now!"

They have talked about lobbing flights such as that of the X-15. Presumably, they too will orbit men—and probably women. But there is strong evidence that even now they are getting ready for the moon itself.

Both the Russians and the Americans are feverishly conducting research to discover how well man can withstand the rigors of the trip to the moon. Not only did the Russians shoot their famous Laika around the world, but on August 27, 1958, (and this is not too well known) they lobbed two



RUSSIAN conception of rocket ferry has boosters that glide back to earth, a return ship mounted on nose

other dogs to a height of 279 miles. The dogs and the instruments were recovered successfully. Many other shots with animals have been made. Only now are we beginning to have some success in lobbing animals. But Russian animals have been the real pioneers of space.

In view of this, I expect that we earthlings called Americans will hear within the next six months that Russia has hurled the first human passenger into space and returned him safely.

Recently Prof. G. V. Petrovich of the U.S.S.R. Academy of Sciences gave hints of still other projects. "The Soviet Union is pushing space research simultaneously in a number of directions: The creation of additional earth satellites, both manned and unmanned; intensive study of the moon; interplanetary flight, including the launching of additional satellites around the sun; manned stations in space tens of thousands of miles away from earth." These stations would be used as intermediate points on spaceship journeys from the earth to other planets.

Russia will also create artificial satellites around the moon, and will place "softly" upon the moon heavy containers with scientific instruments and television cameras.

(Continued to page 222)

Monorails

Will They Ever Get Off the Ground?

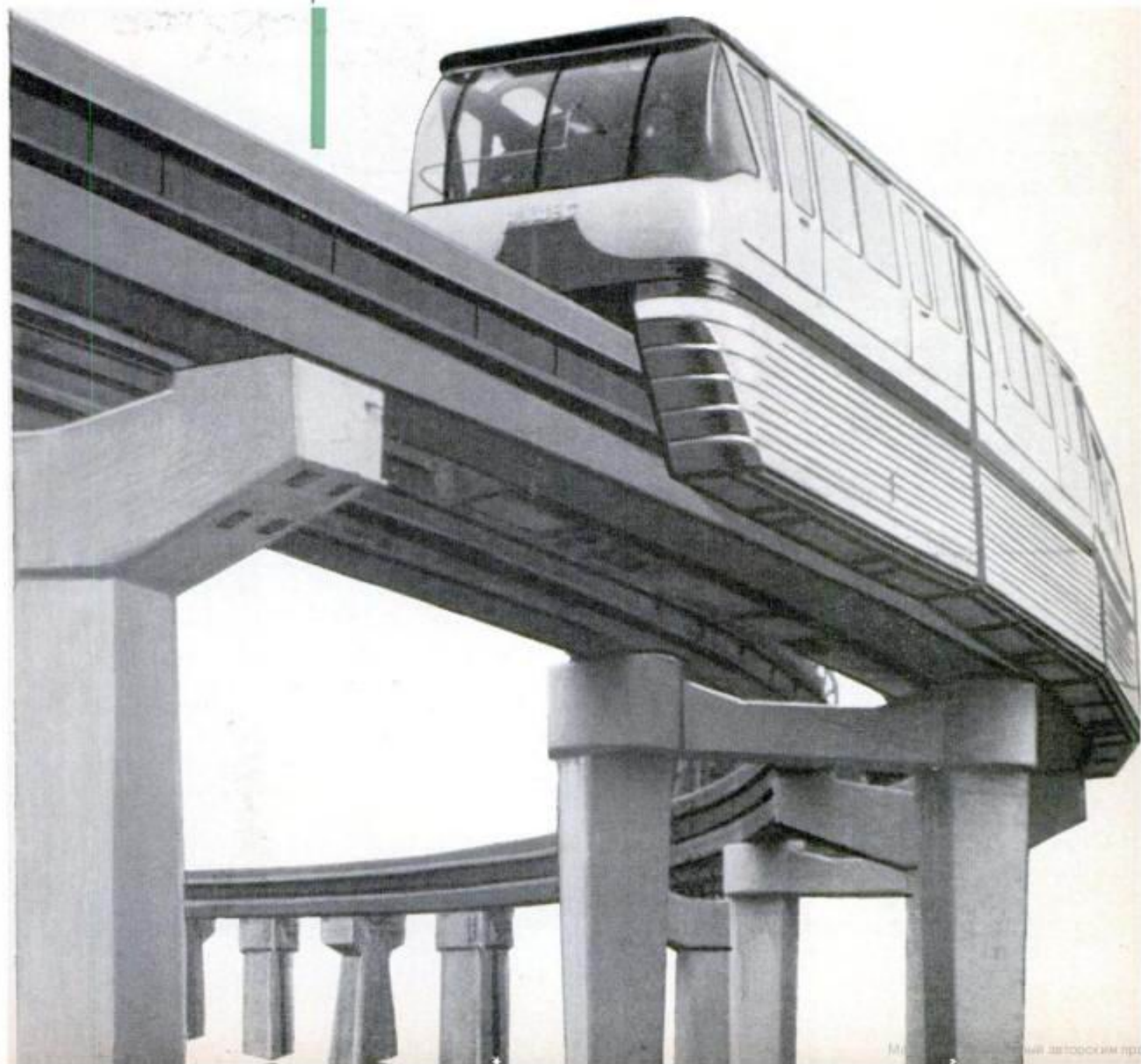
"Why hang railroads from lampposts?" ask the critics. Monorail backers have some answers

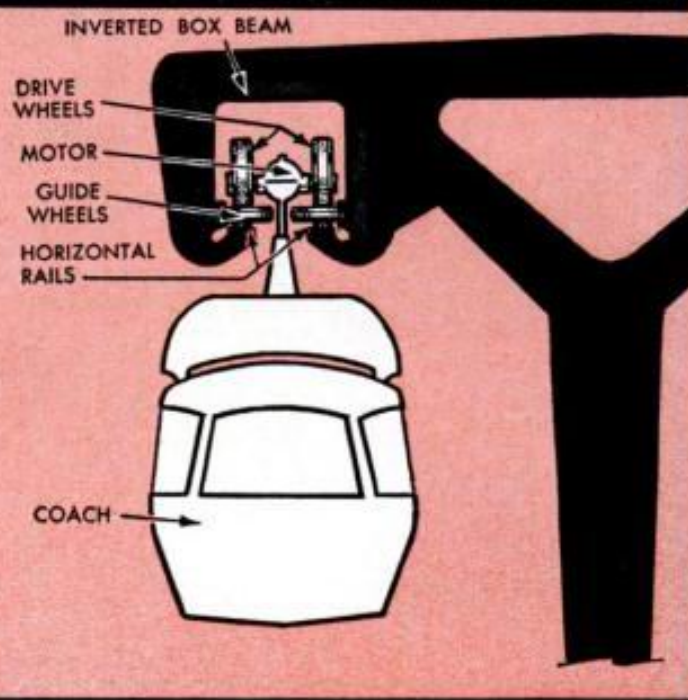
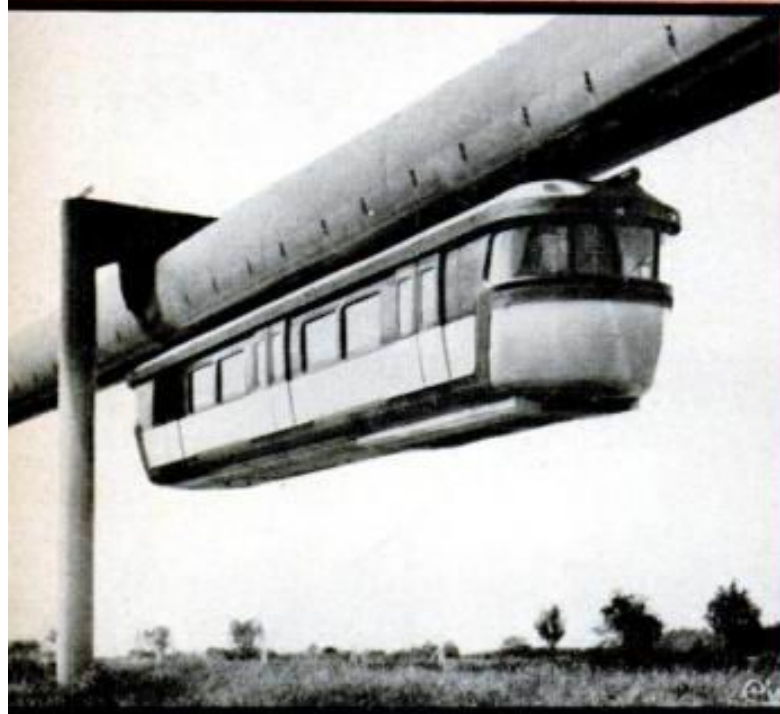
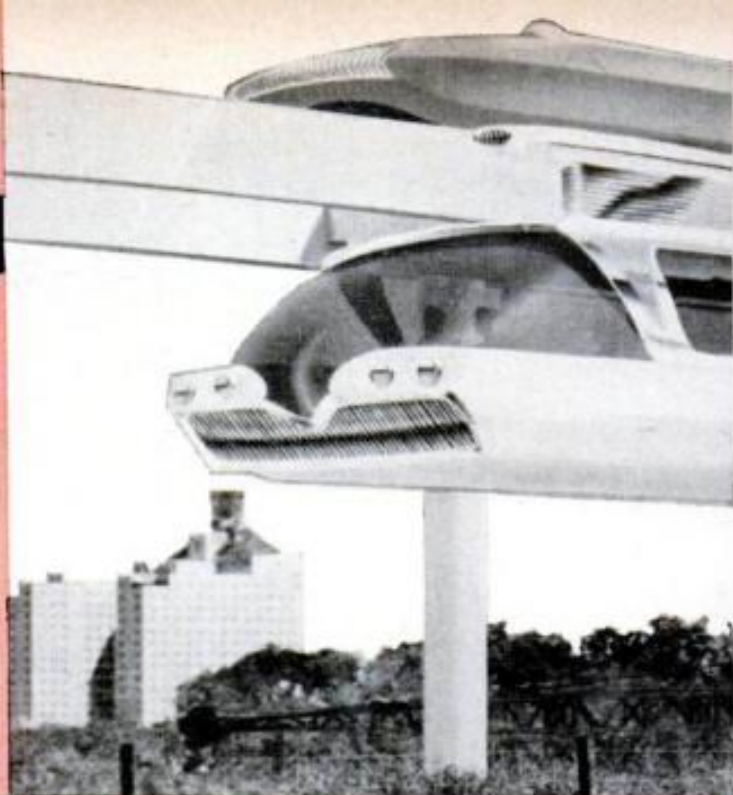
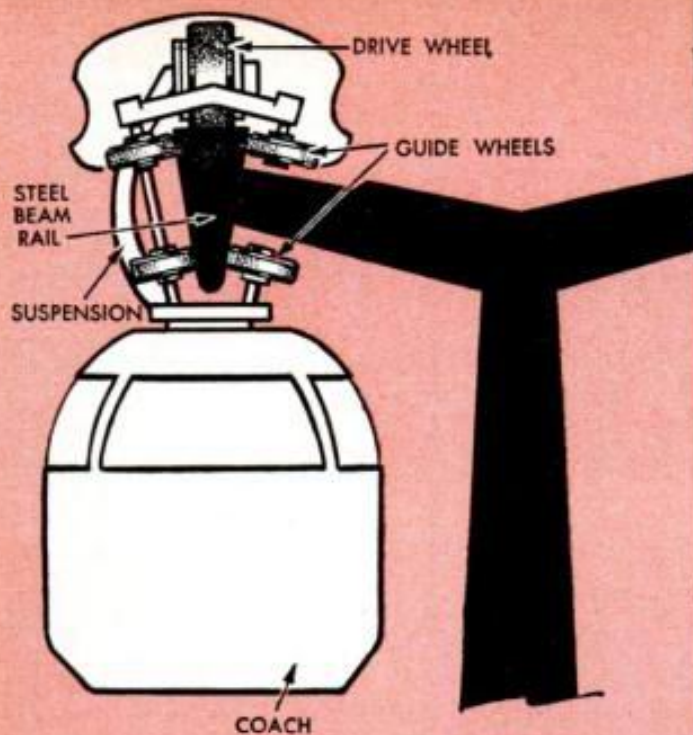
By Joseph N. Bell

WHY TURN A RAILROAD upside down—or suspend it on lampposts—when there's no evidence it will operate better that way?

So argue the opponents of monorail transit systems. And what do monorail advocates have to say in its defense?

- We can erect monorail systems faster than you can build





GOODELL TRAIN (top panel) is suspended from rubber-tired bogies that ride on a triangular steel rail 20 inches wide on top. An electrically powered Goodell system is being considered for a 17-mile Los Angeles airport run

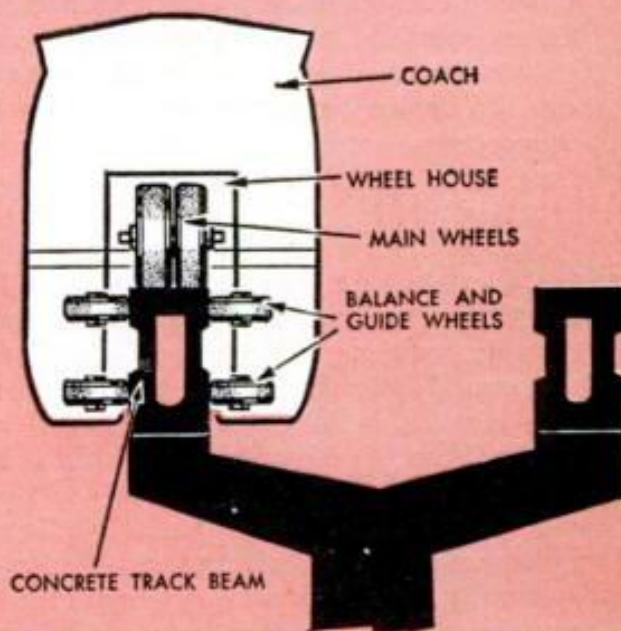
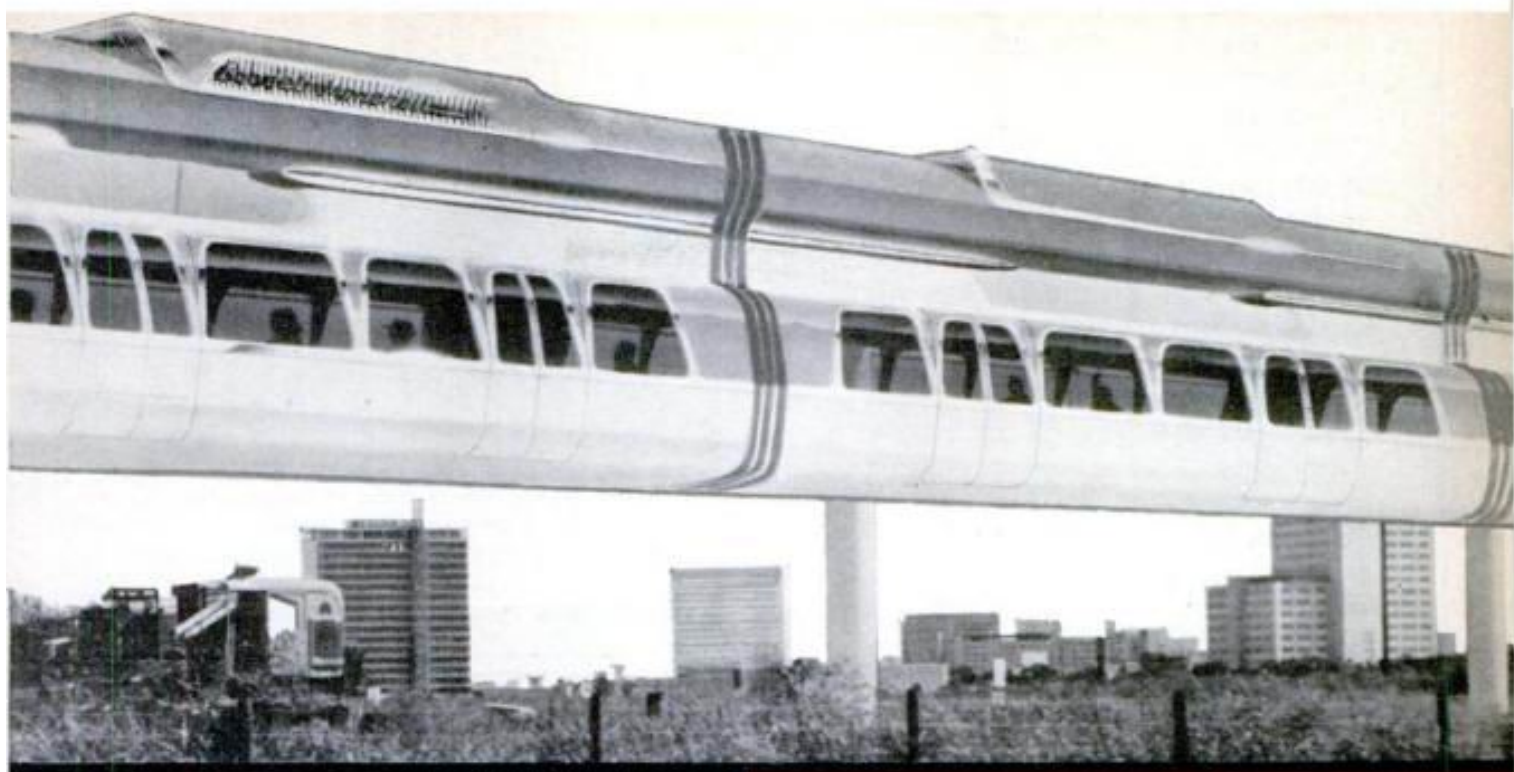
other rail networks—and use less right of way, they say.

- We can build at a lower cost.
- We can offer a city safe, swift and comfortable transportation—and we can serve outlying areas with greater speed.

But to date, the critics have successfully derailed the plans of monorail builders to set up their trains in U.S. cities. Monorails have not yet been allowed to show what they can do as a full-fledged mass-transit system, carrying shoppers and commuters to town, or travelers to an airport.

The few monorails that have operated in the U.S. in recent years have been either experimental setups or installations of relatively short rides to or within expositions and amusement parks.

What's holding back the monorail—which proponents contend will rapidly help solve the strangling traffic problems of big cities? And why should monorails, which by definition are simply one-track railways, have any advantages over the conventional subway, elevated, or bus transportation system?



SAFEGE suspended-type monorail (below, left-hand page) is AMF's high-speed system; box rail is 6 by 6-foot hollow steel or concrete beam. Alweg (above) has its supported system in Seattle; tires run on a 3 by 5-foot concrete beam.

The "one track" is generally not just the familiar steel rail. In the case of the Alweg monorail, for instance (Alweg built the train systems for Disneyland and the Seattle World's Fair), it's a 3 by 5-foot concrete beam.

Vehicles using the monorail track are either the *suspended* type, hanging from the rail above, or the *supported* type, riding atop or straddling the rail.

But, the critics contend, when you hang a train from a single rail—or beam—it tends to sway, and its coaches are buffeted

as the trains pass in opposite directions.

PM reporters riding both the Alweg straddle-rail system in Seattle and the Goodell suspended system in Dallas noted no sway problem. Both systems, however, were running at substantially lower than the capacity speeds which presumably would be a maximum test of sway tendencies. They reported both rides to be surprisingly smooth and far quieter than conventional subway rides.

Alweg officials insist that claims of buffeting between passing monorail cars have

been completely disproved by the operation of the Seattle monorail. And a PM reporter riding the train found that there is no buffeting as trains pass.

"There is no buffeting or tilting of passing cars in Seattle, even at high speed," an Alweg spokesman said. "The distance between passing trains is about 2½ feet, permitting trapped air to escape both upward and downward, resulting in a minimum of tilting. Stabilizing wheels also minimize the tilting motion of Alweg trains." In the New York subways, the widest cars (10 feet) pass within two feet of each other.

The stabilizing wheels of the Alweg trains have also served to neutralize the sway problem—at least at speeds that are compatible with city operation.

Do Suspended Types Sway?

What about sway and buffet problems on the suspended type of monorail? Murel Goodell of Goodell Monorail Systems says, "Our inertial guidance system entirely eliminates the sway problem. It operates on the same principle as a gyroscope, where you can't have sway and where long-term undulations are simply counteracted."

(Goodell personnel have built three U.S. installations and Goodell Monorail, Inc., currently has an active proposal for a 17-mile system serving the Los Angeles airport. The design shown on the cover of this issue is, in fact, one that Goodell will exhibit at the New York World's Fair next year.)

PM reporters' rides of the Dallas Goodell system could establish no facts concerning buffeting inasmuch as only one train was running. When trains run both ways, Goodell says, there'll be a minimum of four feet between passing cars.

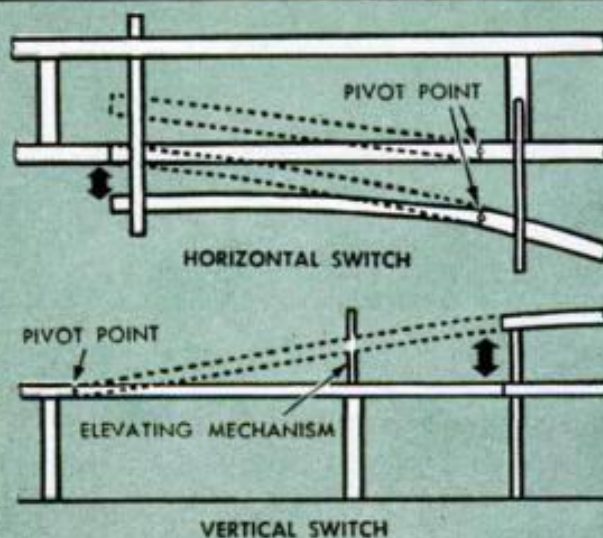
However, the maze of guiding and stabilizing wheels on modern monorail designs has given the critics an opening for an argument about semantics. The term, "monorail," insist many transit engineers, is a misleading misnomer.

Look at a system that has six lines of wheels, commented one engineer. "If they used rails, they would need six, and that isn't monorail to me. This system is just an electric bus running on top or beneath a concrete beam."

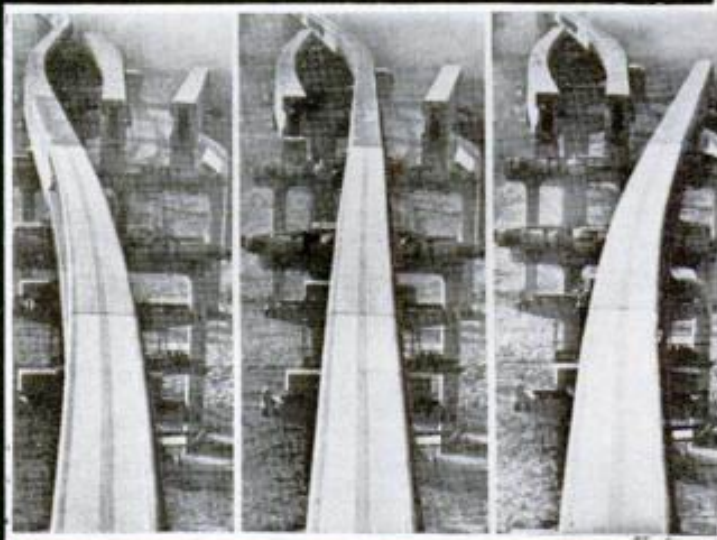
Whatever the number of wheels, some say, monorails don't go fast enough on them to gain a speed advantage.



IT CAN HAPPEN—as it did at Los Angeles County Fair when a bolt snapped. However, suspension system isn't type used on fast mass-transit train



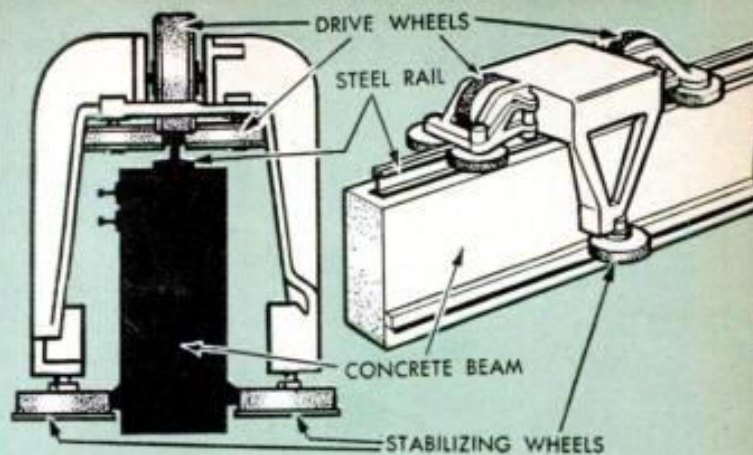
GOODELL HORIZONTAL SWITCH (top) is an 80-foot section that moves into place as main line swings out. Vertical switch is section that rises



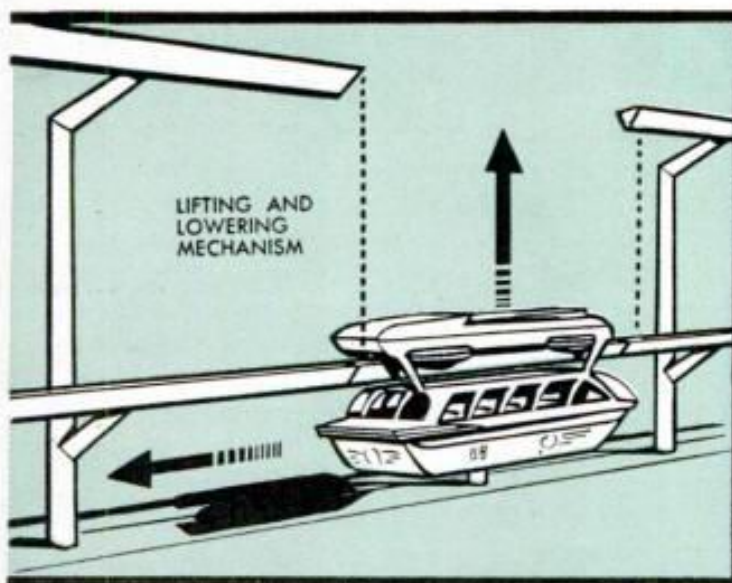
HIGH-SPEED SWITCH for Alweg system is a flexible aluminum beam 140 feet long. Beam flexes to side in seven seconds to allow coach to switch



NIHON-LOCKHEED system is one of several in Japan. Electrically powered train has pneumatic system to keep floor level and align it with passenger platform



DUAL DRIVE WHEELS (two in-a-line on each bogie) carry Nihon-Lockheed coaches on single steel rail mounted on concrete beam. Lower wheels stabilize car



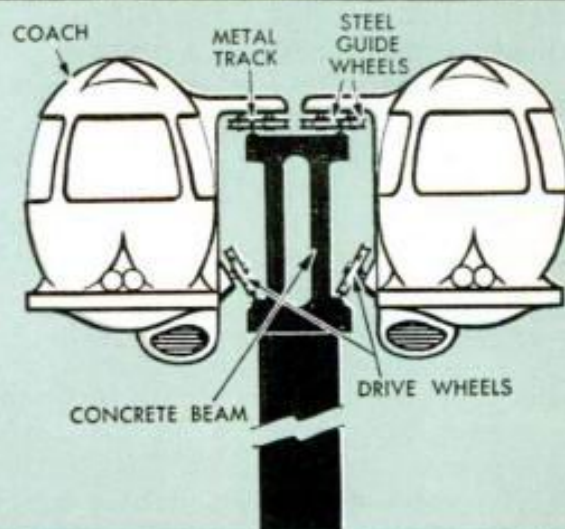
COACHES of Goodell system are taken off the main line for storage or repair by lowering a section of main line and driving coach off onto a "siding"



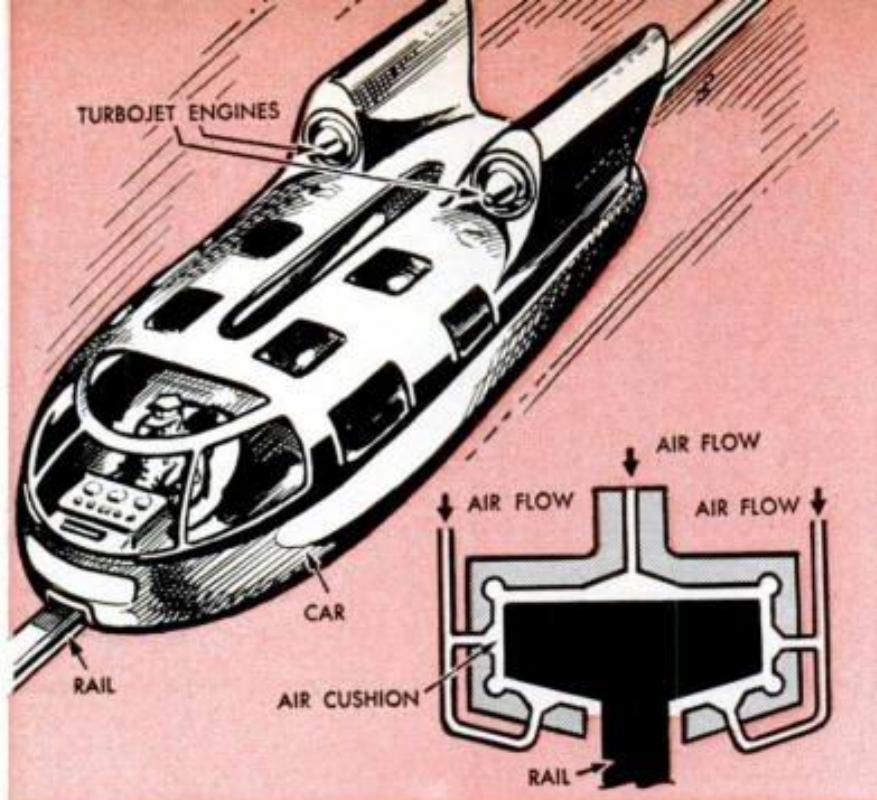
WORLD'S FAIR RIDE, being built by American Machine & Foundry Co., will be in use in New York next year. It runs on lower flange of a 4000-foot I-beam track



PRECAST CONCRETE COLUMNS of Alweg system hold both beams for two-way train traffic but still allow surface traffic to flow easily. Rail height is 25 feet



SCHERER MONOBEAM is new concept. Main feature is two-way traffic on single concrete beam, with wheels running on steel rails. The structure stands 23½ feet



FOMOTION is a monorail design by Ford Motor Co. It would slide on a single rail, supported by a thin cushion of air. Two turbojet engines propelling the car would also supply the air flow for "levapads" in the slipper (support) that holds the car on the rail

"The speed capability of monorail is no greater than standard rapid-transit equipment in normal urban and suburban service," says the Institute for Rapid Transit.

Serious monorail builders have perhaps been handicapped by the comparisons between attainable speeds and the 200 miles-per-hour speeds often loosely tossed about in "dream" systems.

Such high speeds can be attained only where there are no intermediate stops.

Virtually the same speeds can be achieved on two rails as on one, since speed is a function of horsepower in relation to weight. Under a city's stop-and-start conditions, only a greatly improved rate of acceleration and deceleration could speed up service—and monorails do not accelerate or decelerate faster than two-rail cars of the same power and weight.

Alweg expects to average 35 m.p.h. in a proposed 43-mile Los Angeles system and says it has averaged that speed with its Seattle monorail. The Seattle trains, on a 1.2-mile track, are designed for a top speed of 70 m.p.h. The monorails' in-city speed is slightly higher than the 30 m.p.h. averaged by surface trains in Cleveland and subway trains in New York City.

The monorail that Goodell has proposed for Los Angeles faces a different circumstance. The line is almost a straight shot from downtown 17 miles to the airport. The coaches, capable of 90-m.p.h. speeds, will be scheduled to cover the 17 miles in

12 minutes—an average speed of 70 m.p.h.

(Goodell feels that monorails can best be used in such an airport-to-downtown run. With few intermediate stops, the train can achieve high speeds. Another important use, the firm believes, would be from automobile parking lots in fringe areas to the center of a city.)

The granddad of operating monorails, the Wuppertal system in Germany, offers a sidelight on average speeds. Its trains sustain 25 m.p.h. on their 9.3-mile run. That's a respectable average for the old-timer (a suspended-type monorail), which has been in commercial service since 1901. The maximum speed allowed the coaches is 31 m.p.h.

Those trains of the Cleveland Rapid Transit—regarded as one of the best double-track transit systems in the nation—serve 14 stations on a 15-mile route while maintaining their 30-m.p.h. average. The Cleveland system is a surface line with 88 electric cars.

Subway trains in New York, equaling that 30-m.p.h. average, have a top speed of 45 m.p.h., says the City Transit System. Buses in New York average 9 m.p.h.

Admitting that the arguments so far don't give the monorail any sort of spectacular operating advantage, proponents move on to the question of the original cost of a transit system. Here, they feel, a clear-cut advantage appears.

(Please turn to page 191)

Make Your Yard a Christmas Card
Six New Holiday Season Project-a-Plans

POPULAR MECHANICS

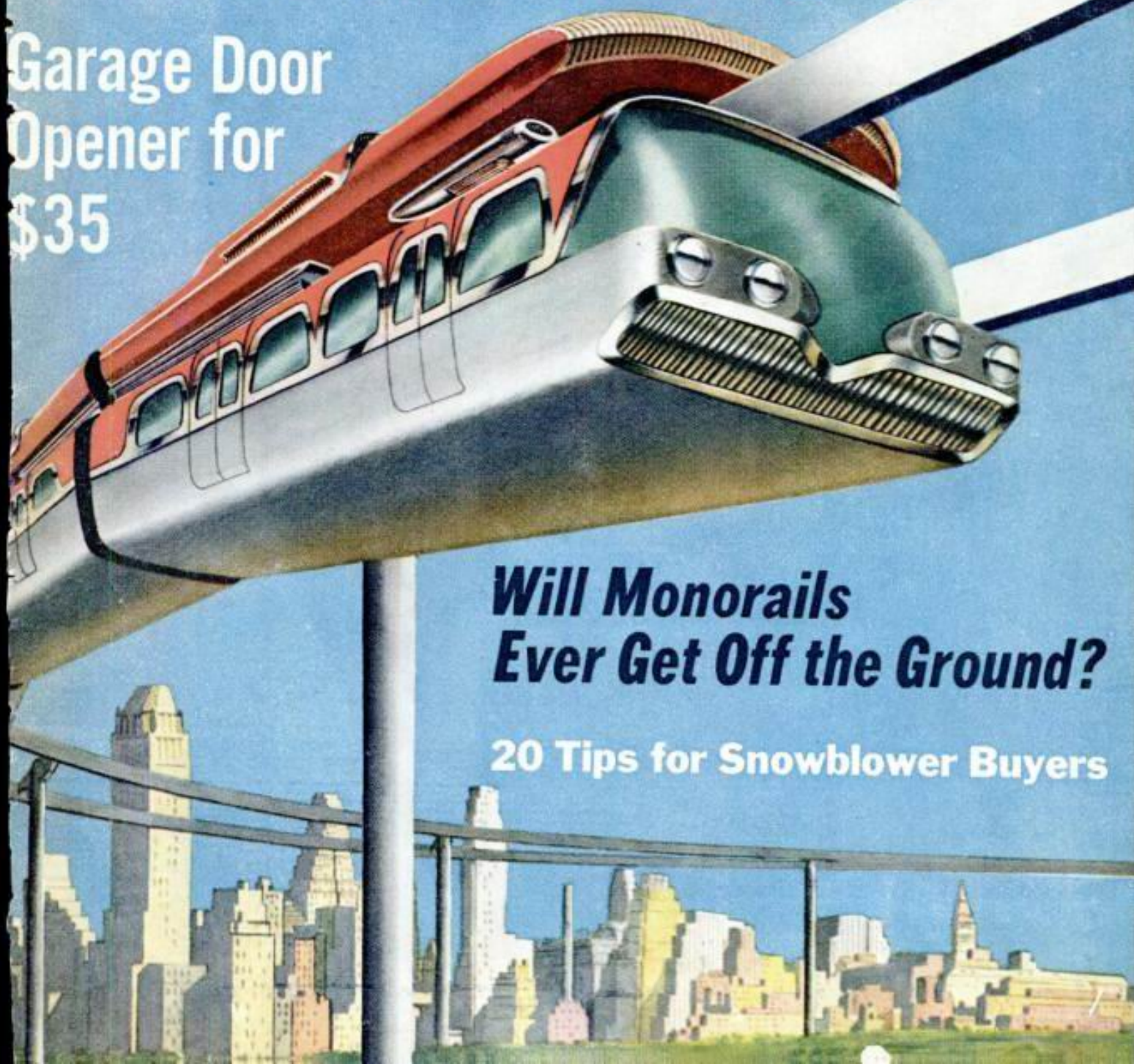
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How to Find Honest TV Service

**Garage Door
Opener for
\$35**

***Will Monorails
Ever Get Off the Ground?***

20 Tips for Snowblower Buyers



Preview: THOSE '63 CARS!

POPULAR MECHANICS

AUG 1962
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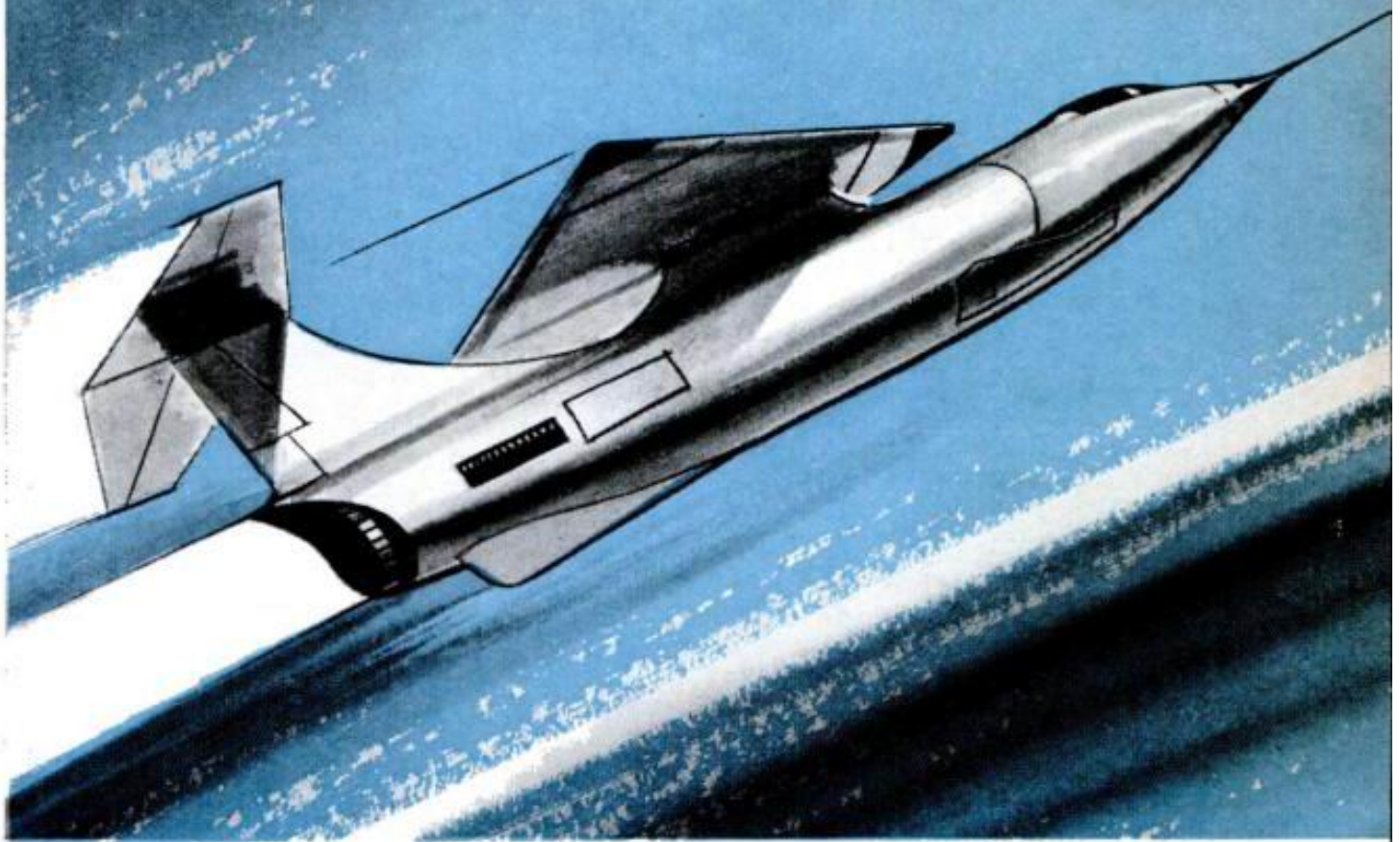
Build a 38-m.p.h. Fun-Boat — for \$38

Secrets of Buying the Best Transistor Radio

Wizards of Wallops Island: Shoestring Canaveral



***Supersonic
Helicopter!***



GIRARD 'HELIPLANE' features stubby delta wing that whirls for vertical takeoff, locks for cruising

SUPERSONIC HELICOPTER

ONE OF THE newest concepts in aviation is a helicopter with a triangular rotor that converts into a fixed delta wing for fast straight-ahead cruising—at up to Mach 2, twice the speed of sound.

It is the only design that uses the same lifting device for hovering and cruising, yet transitions from one operation to the other while in flight.

This paragon of VTOLs hasn't yet been built, but its theoretical calculations look so promising that aerodynamicists have become intrigued by it.

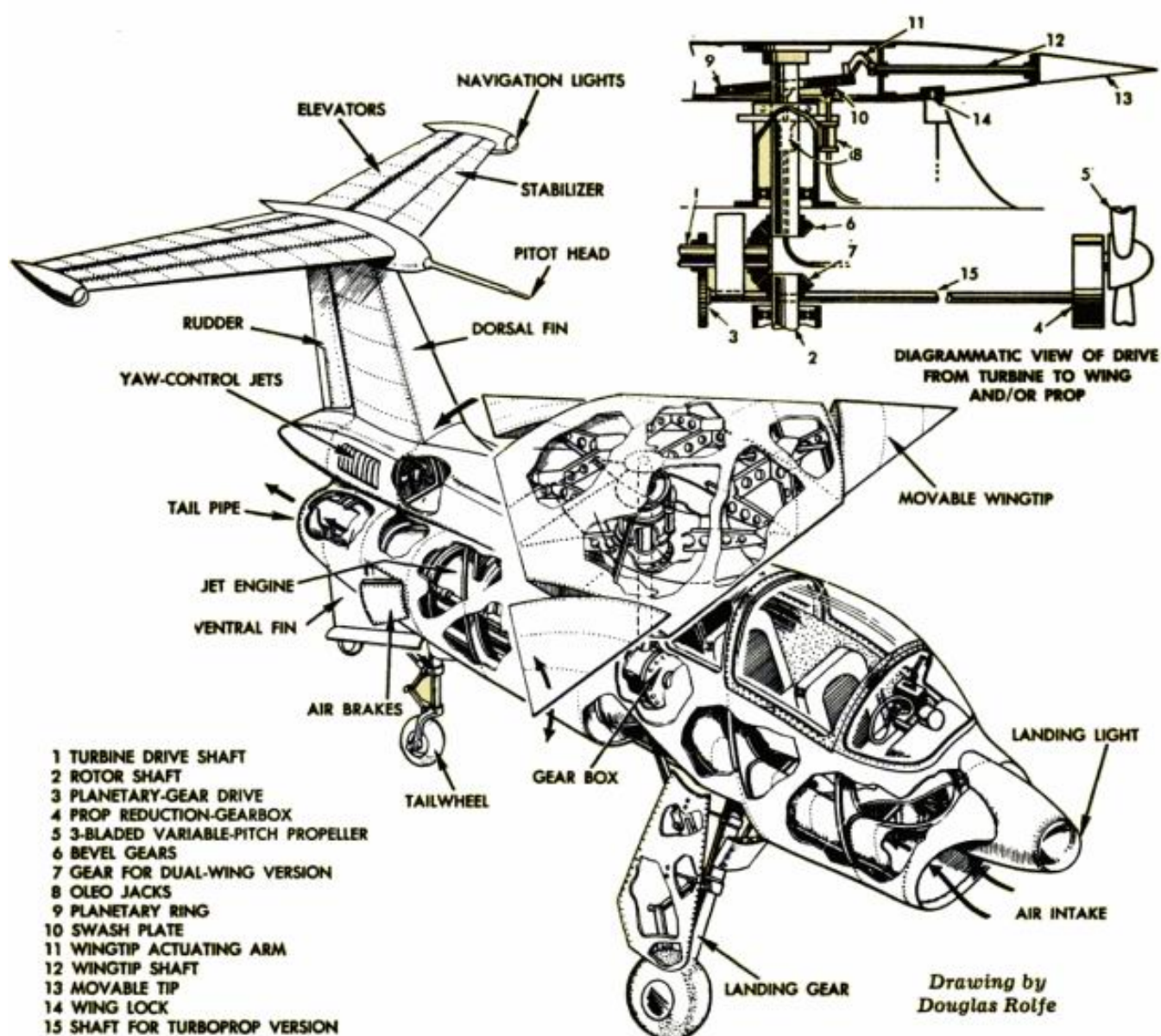
The "heliplane" is the patented invention of P. F. Girard, project engineer of special projects at Ryan Aeronautical Co., San Diego, Calif. Pete Girard is an old hand at vertical-takeoff machines; he was test pilot for Ryan's spectacular X-13 *Vertijet* a number of years ago. He has served as chief aerodynamicist and also as chief of prelimi-

nary design on a number of Ryan projects.

His heliplane concept encompasses a whole family of designs ranging from a slow coaxial biplane to a supersonic military recon machine with a single overhead rotor-wing. This craft, with a fuselage resembling that of an F-104 and powered with a J-75 jet engine, would be capable of Mach 1.5 to Mach 2 speeds. It's shown above.

Included in the heliplane family are large subsonic and supersonic VTOL passenger transports having two or more rotor-wings mounted in-line above the fuselage. All would be powered by jet engines. To operate as a helicopter, the jet exhaust would be diverted to an auxiliary turbine that would drive the rotor shaft. All the designs with the exception of the turboprop biplane would use normal jet thrust for ordinary cruising.

Photographs on page 69 show two $\frac{1}{20}$



scale models of a typical heliplane. It is a two-seater that would be powered with a J-60 engine of 3000-lb. thrust and would cruise at around 500 m.p.h. The full-sized craft would be about 40 feet long and its triangular wing would measure some 22 feet on a side. The craft's three-point landing system consists of two wheels that retract into the fuselage under the cockpit, and a wheel under the tail that retracts into the ventral fin that also helps provide stability.

One picture shows this craft as a biplane with one wing above and the other below the fuselage, an arrangement that contributes to dynamic stability. Another picture, with the lower wing removed, shows its appearance as a high wing monoplane. (As a monoplane the single rotor-wing would be somewhat larger than the one pictured.)

The tips of the three-sided wing are hinged so that they can be tilted to act as lifting surfaces when the wing is rotated. The tips are geared for both collective and cyclic pitch. Girard points out that most

of the lift from a helicopter's rotor is created by the outer portions of the blade, and that the heliplane follows this concept.

After lifting off vertically from the ground and climbing out at a steep angle, the pilot would transition to a fixed-wing configuration by diverting power from the rotor turbine and applying the power as tail-pipe thrust. The rotor would rapidly slow down and stop, automatically locking into delta-wing position. At the same time, the rotor tips would orient to zero angle and become part of the airfoil.

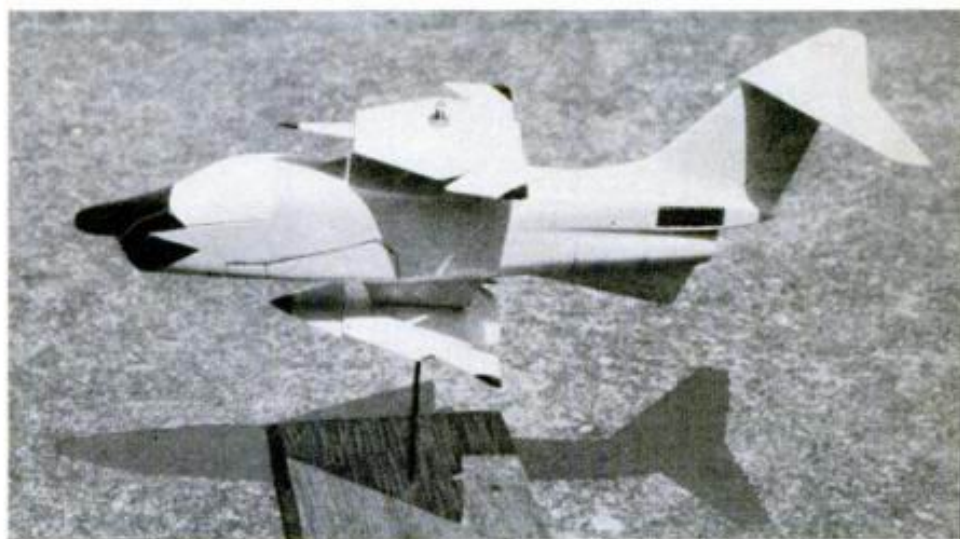
To land his craft, the pilot would descend to around 1500 feet, slow down almost to stalling speed and unlock the wing, allowing it to function again as a rotor and meanwhile applying the power to the rotor's turbine. Going from one configuration to the other or back again appears to offer no special structural or control problems. In case of engine failure the wing could be allowed to auto-rotate to let the craft down fairly safely.

Most helicopters use a small tail rotor as an antitorque device, to prevent the fuse-

CUTAWAY VIEW (left) shows basic principles of heliplane. Unlike most VTOLs, it needs only one engine, including power for forward speed, whirling wing and yaw jets. Diagram in upper right shows how power is geared to wing or prop for turboprop version of heliplane



PETE GIRARD (right, above) holds model of single-wing version. Model of biplane version (right) shows wings above and below fuselage. They would whirl in opposite directions to counteract the effect of torque



lage from spinning with the rotor. Girard's biplanes need no such assist because the contrarotating upper and lower surfaces cancel out the effect. For his monoplane designs he would bleed off some of the jet gases through a side louver at the tail to counteract torque and also to provide directional control while hovering.

Girard's calculations show that the heliplane has a "figure of merit" of 75 percent as compared to 70 percent for a conventional helicopter. "When compared to many other types of VTOLs, the weight that can be lifted by this design appears to be very high in relation to horsepower," he says.

"Most VTOL designs have relatively high disk loadings, while the heliplane can be tailored to low disk loads. This provides good lift characteristics at the same time that the wing remains small enough for high forward speeds. This is an asset in the civil market where costs must be kept low."

As one part of the simplicity of his design, Girard points out that the heliplane requires only one gear box as against from three to fifteen in some VTOLs.

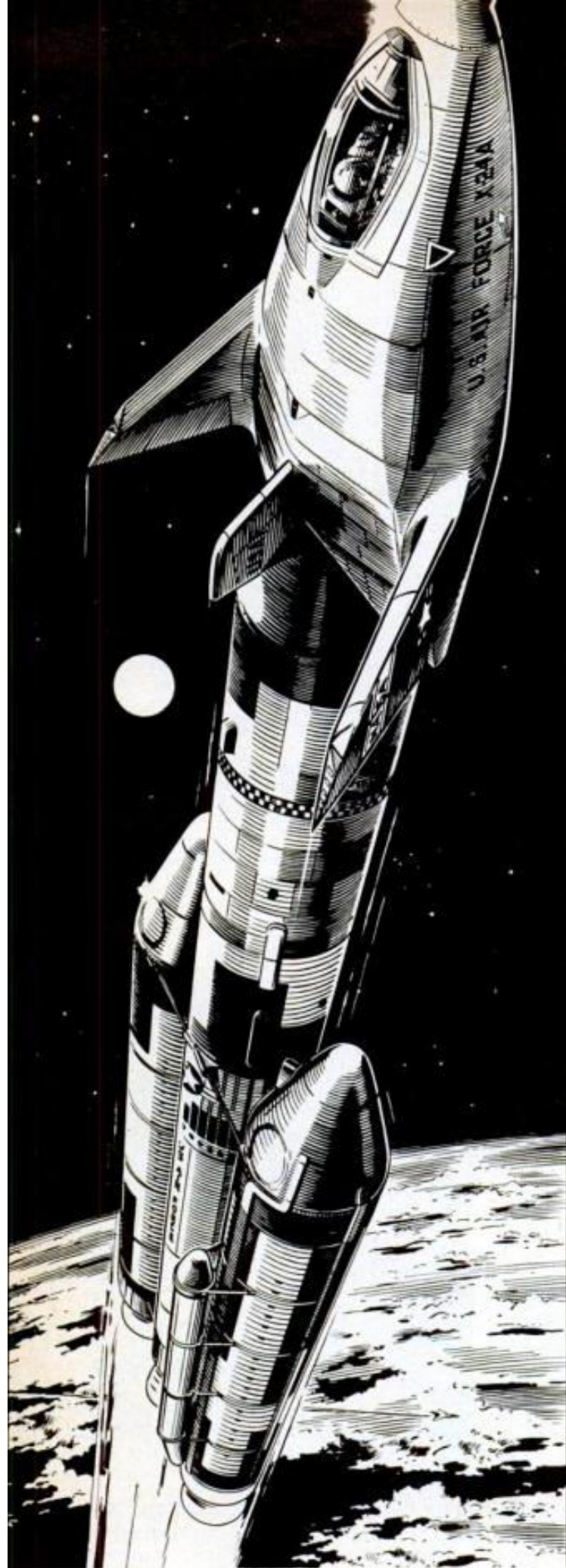
Another desirable feature is that the rotor-wing is of the rigid type. It's not hinged at the rotor head. The usual helicopter with a hinged rotor has a very narrow center-of-gravity range and its cargo must be stowed near this center of gravity. The rigid rotor, on the other hand, allows a wide latitude in center of gravity and a pilot can compensate for poor balance by adjusting the cyclic pitch. It's a safer machine.

All this sounds exciting, so when will the first heliplane be wheeled out for flight tests? It's hard to say.

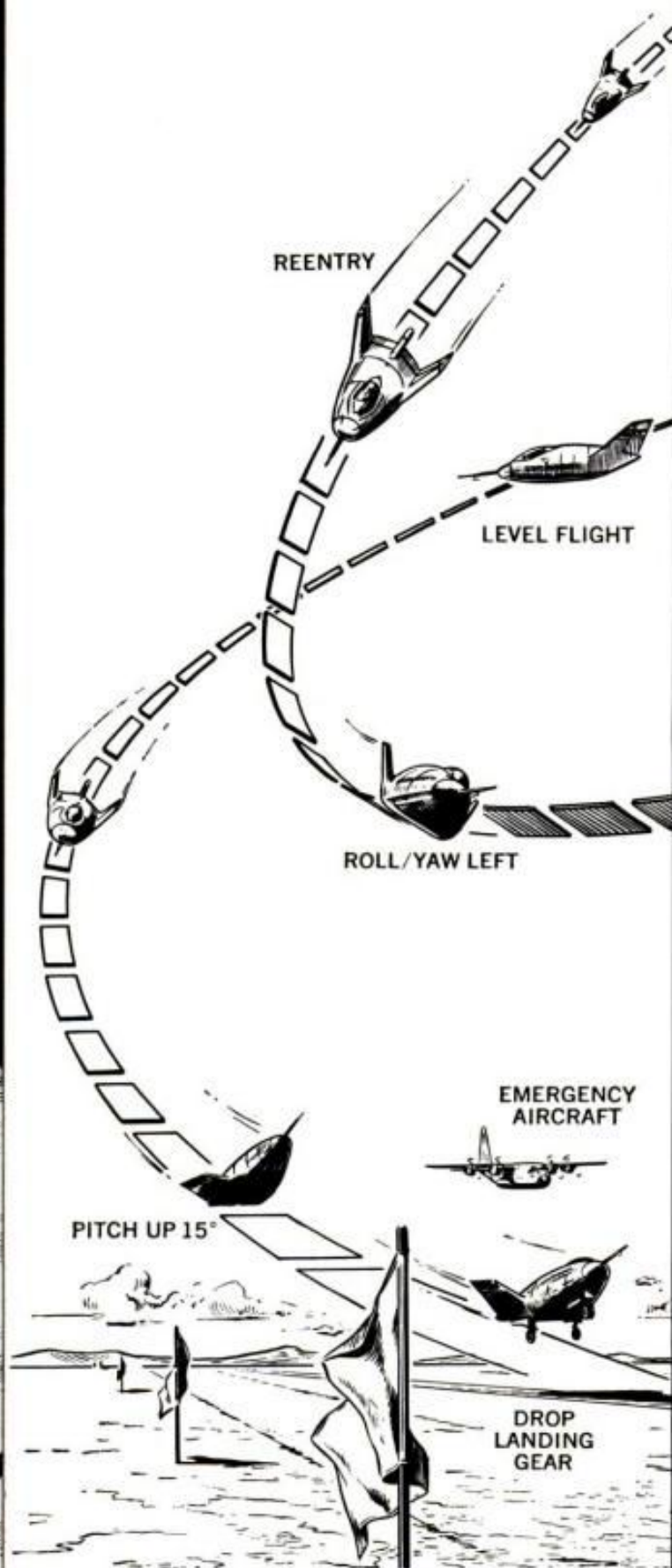
All Girard's work so far has been exploratory. As this story was written, he was preparing to test the performance of his three-pointed rotor with a power-driven model. Patent rights have been assigned to Ryan Aeronautical, as is customary in industry.

If Girard's tests confirm his calculations, more research will follow. And, if all goes well with the research, it might not be too long before his unique idea for a heliplane becomes a reality!

★ ★ ★



LIFTING BODY, in art concept (left), lifts off on top Titan III booster en route to space, just like spacecraft. Landing, however, is different. It becomes an aircraft, skipping back into atmosphere to slow down to flying speeds, then heading for conventional airport. Such landings eliminate awkward problems of picking spacecraft from ocean

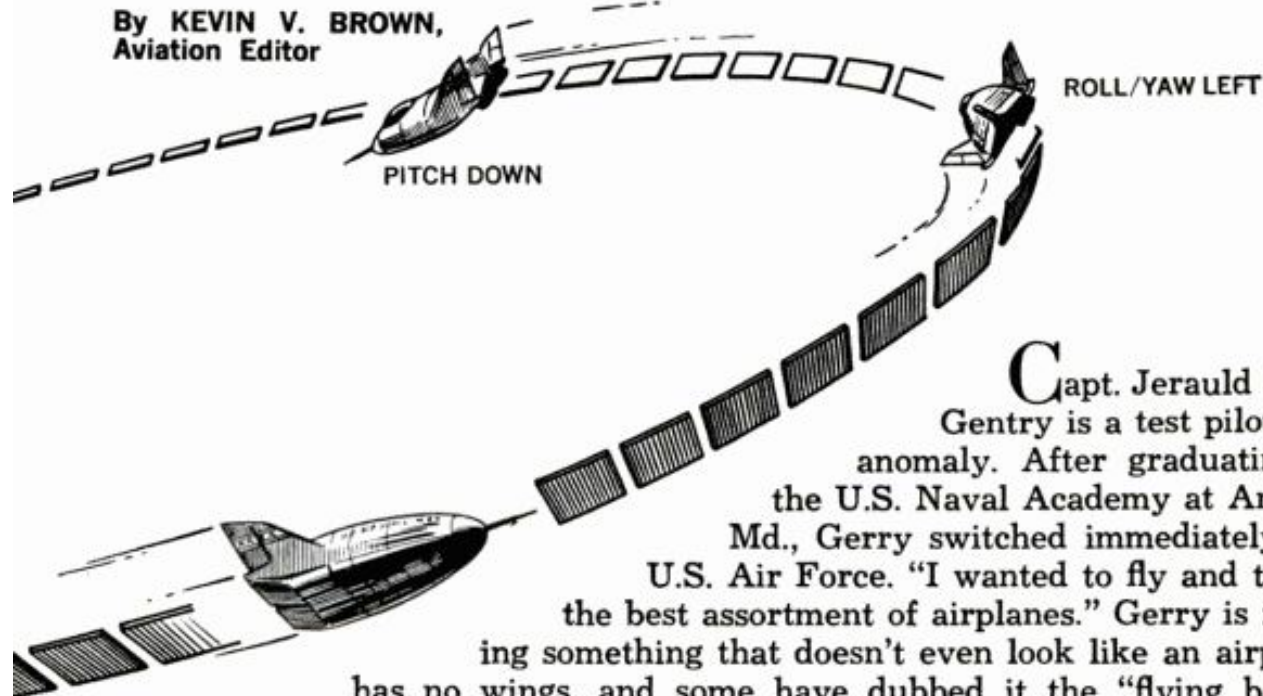


REENTRY

Our Wingless Airplane That Flies in Space

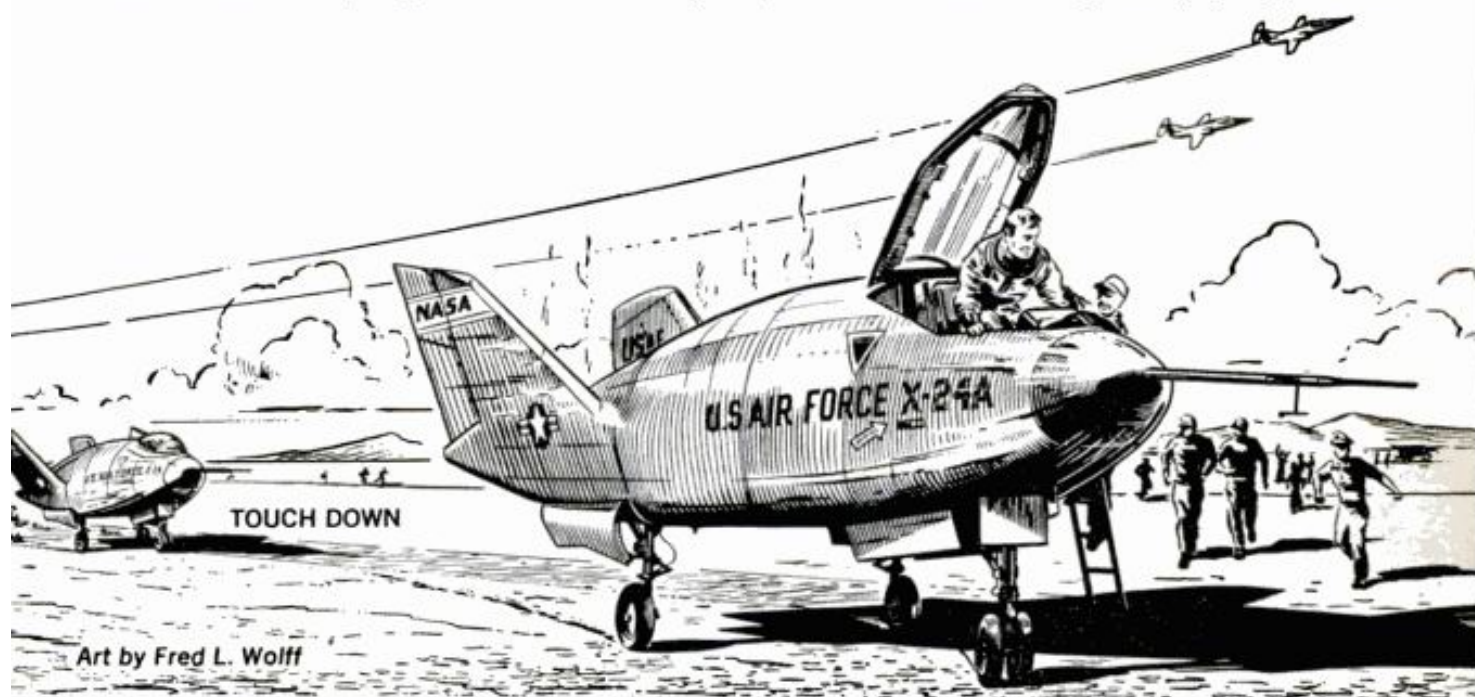
The 'lifting body' may be our next spacecraft, riding into orbit on a rocket but flying back and landing like a plane

By KEVIN V. BROWN,
Aviation Editor

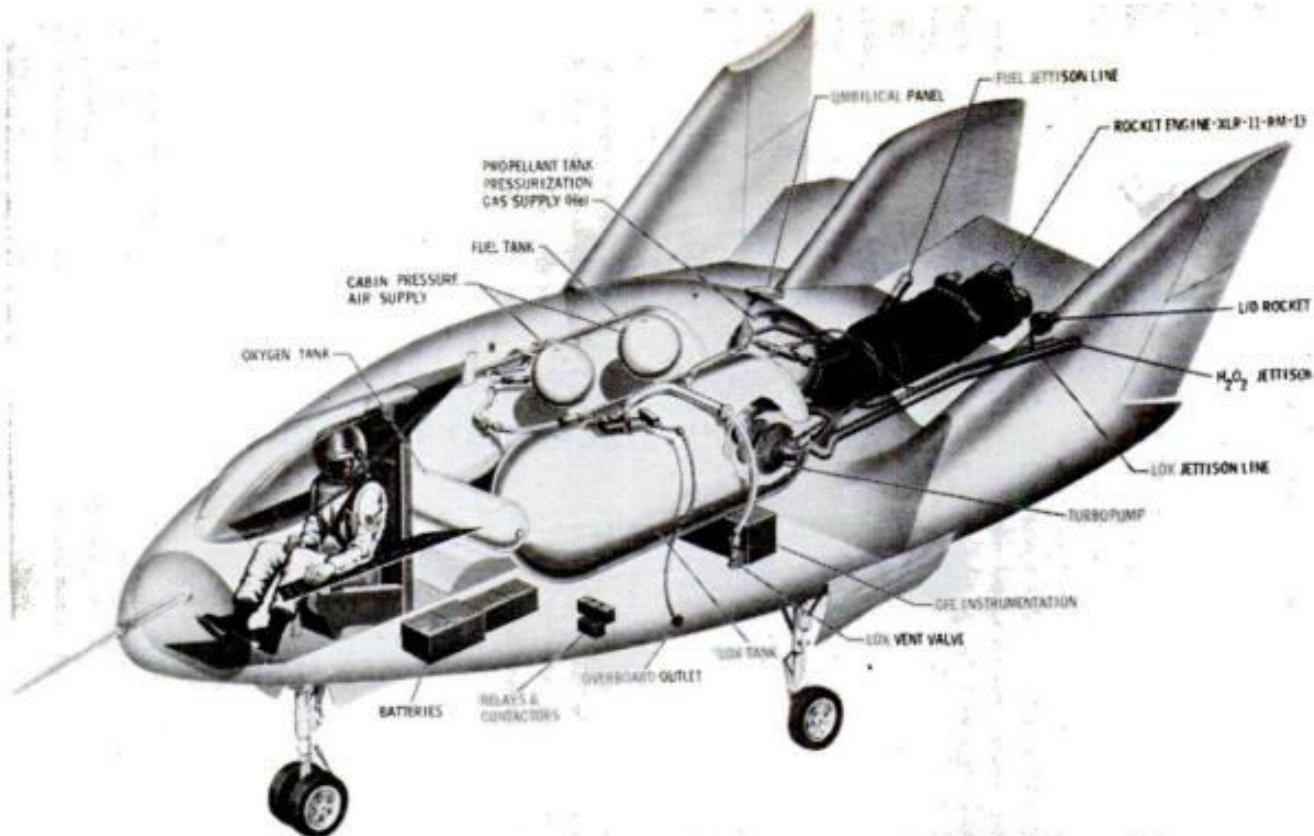


Capt. Jerauld (Gerry) Gentry is a test pilot and an anomaly. After graduating from the U.S. Naval Academy at Annapolis, Md., Gerry switched immediately to the U.S. Air Force. "I wanted to fly and they had the best assortment of airplanes." Gerry is now flying something that doesn't even look like an airplane. It has no wings, and some have dubbed it the "flying bathtub."

Captain Gentry is project pilot on the Air Force X-24, the so-called "lifting body" program. This summer, for the first time, Gerry will fly the bathtub to supersonic speeds. Some day, he or another anomaly may fly it, or one of its descendants, right on out into space, because the lifting body program is



Art by Fred L. Wolff



CUTAWAY VIEW of X-24 shows power unit. Engine is almost identical to those that powered original X-1

intended to find a solution to one of the space program's most vexing problems—the awkward and expensive rescue after each mission of an awkward and

INTREPID AUTHOR flies X-24 simulator. Biggest problem is rapid rate of descent without power

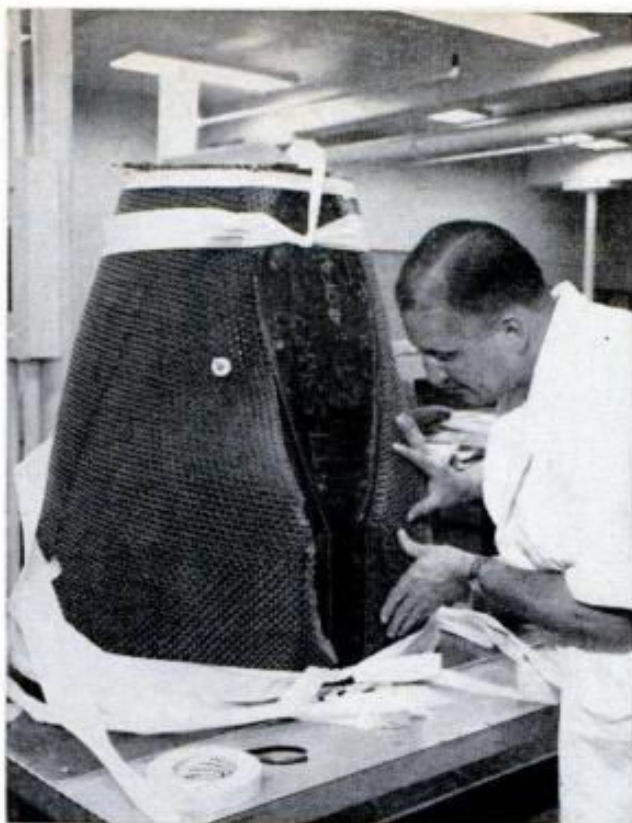


expensive spacecraft that can never be used again anyway.

The X-24, or something like it, instead of landing in the ocean, where the Navy has to go out and retrieve it, can fly itself back into the atmosphere, maneuver like an airplane, then land under its own control at an existing air base.

Such a craft could come down anytime. It would not have to be timed for the moment when seagoing ships were in the right position to lift it from the ocean. In fact, the Navy could get out of the spacecraft-recovery business. More important, the spacecraft itself could be used repeatedly, instead of ending in a museum after one flight.

The lifting-body program goes back several years. It began with the M-2, produced by Northrop Corp. for the National Aeronautics and Space Administration, followed by the HL-10, also by Northrop for NASA. Both of these were dropped from "mother ships," mostly B-52s, then they glided to earth without power but with aerodynamic control like an airplane. Auxiliary rockets in the HL-10 gave it an



ABLATIVE MATERIAL, tested in space on small model, can be stripped off so lifting body can fly again

tain Gentry at the controls, will be the first to use sustained power and will ultimately go supersonic, probably this summer. Its descendants will, in fact, become the first "flying" spacecraft.

I visited Edwards Air Force Base, where the X-24 is based, and talked to Gerry Gentry and some of the others involved in the lifting-body program, and I also flew the lifting-body simulator, neither wisely nor well.

The concept of an aerodynamic-spacecraft, or a ballistic-aircraft, was put to me in simple terms by a Martin man.

"All bodies have aerodynamic qualities, some better than others," he said. "The idea is to find the optimum shape between what you want to put into that body, based on its mission, and what you want that body to do to perform its mission."

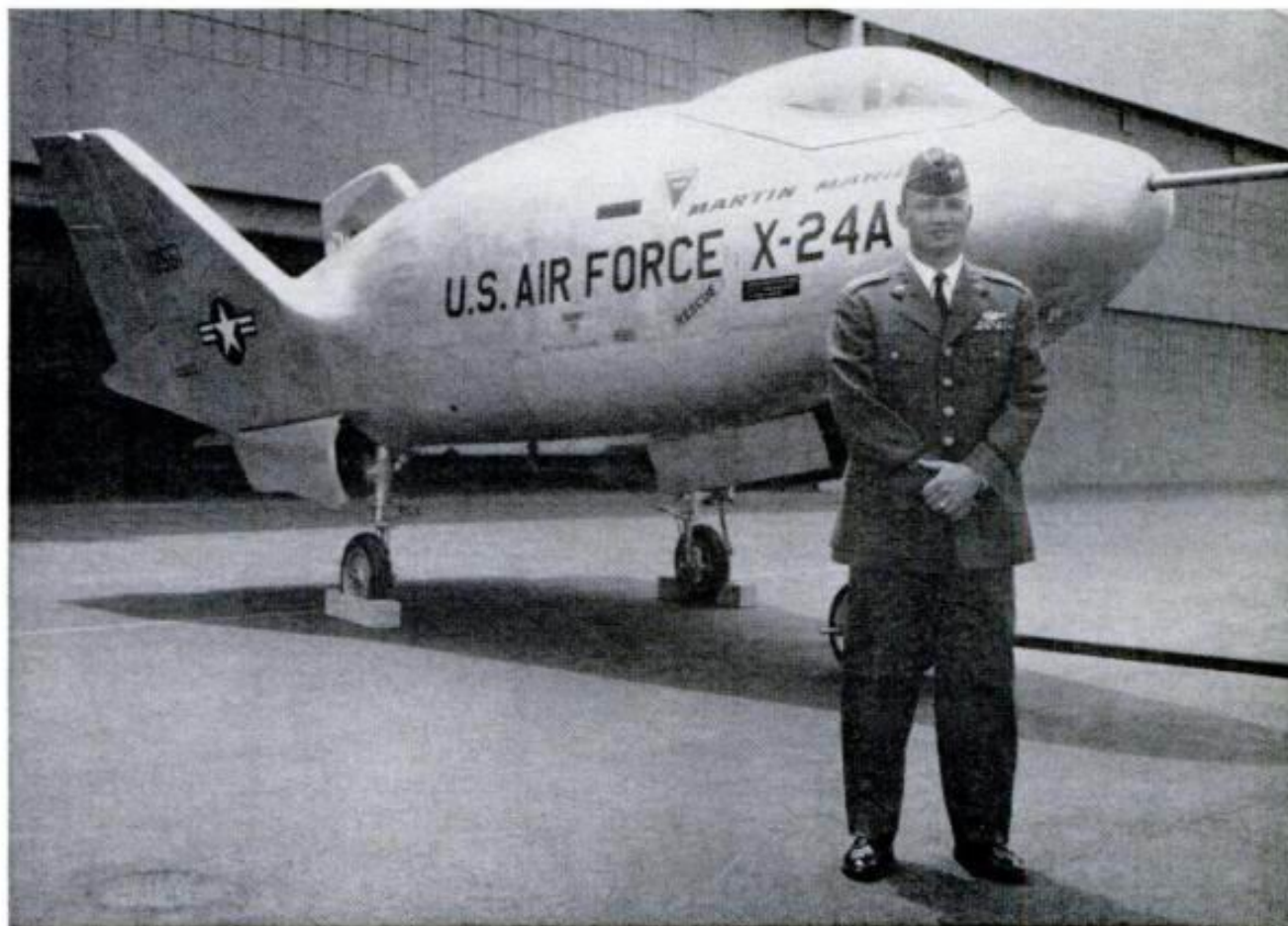
In other words, once you have established what you have to put into the

(Please turn to page 172)

additional boost if needed on landing.

Now the Air Force is getting in on the act with the X-24, produced for it by the Martin Co. The X-24, with Cap-

GERRY GENTRY, project pilot on lifting-body program, will fly X-24 to supersonic speeds this summer



How to Defend Yourself Against 'Damn-Fool' Drivers

POPULAR MECHANICS

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Owners
Reports
Pontiac,
Mercury

HOW ENGINEERS
WILL SHUT OFF
NIAGARA FALLS

Hot New
Houseboats

They Don't
Just Float
Page 90

The X-24 Wingless Plane That Flies in Space

New Tunnel-Hull Inboard,
New Yamaha Outboards
— First Test Reports

IDEAS
TIPS
and
PROJECTS

A Soda Fountain for Your Fun Room ■ A Room Divider
That Makes Music ■ More Cooling From Your Airconditioner
Radio-Controlled Airplane Kit ■ A Hi-Lo Camper for
Your Pickup ■ Handsome Jewel Boxes (Weekend Project)
Automated Lawn Sprinkler ■ Bathroom-Darkroom

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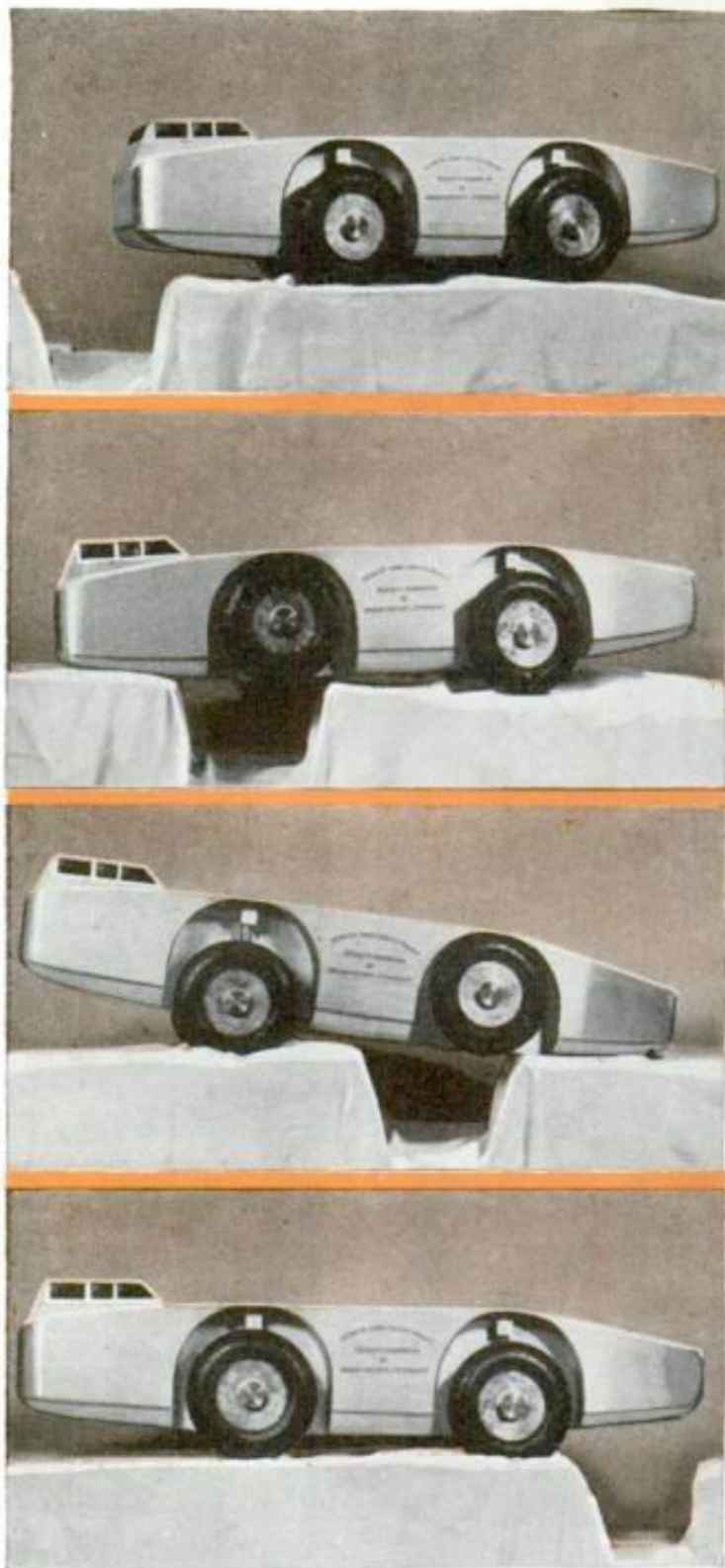
OCT.
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SEE PAGE 494

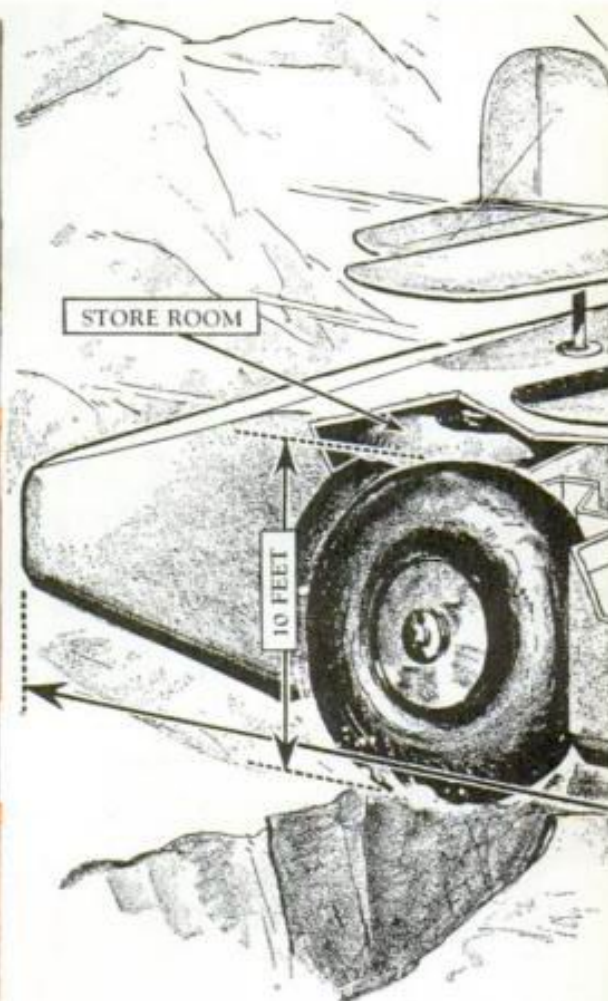
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SNOW CRUISER



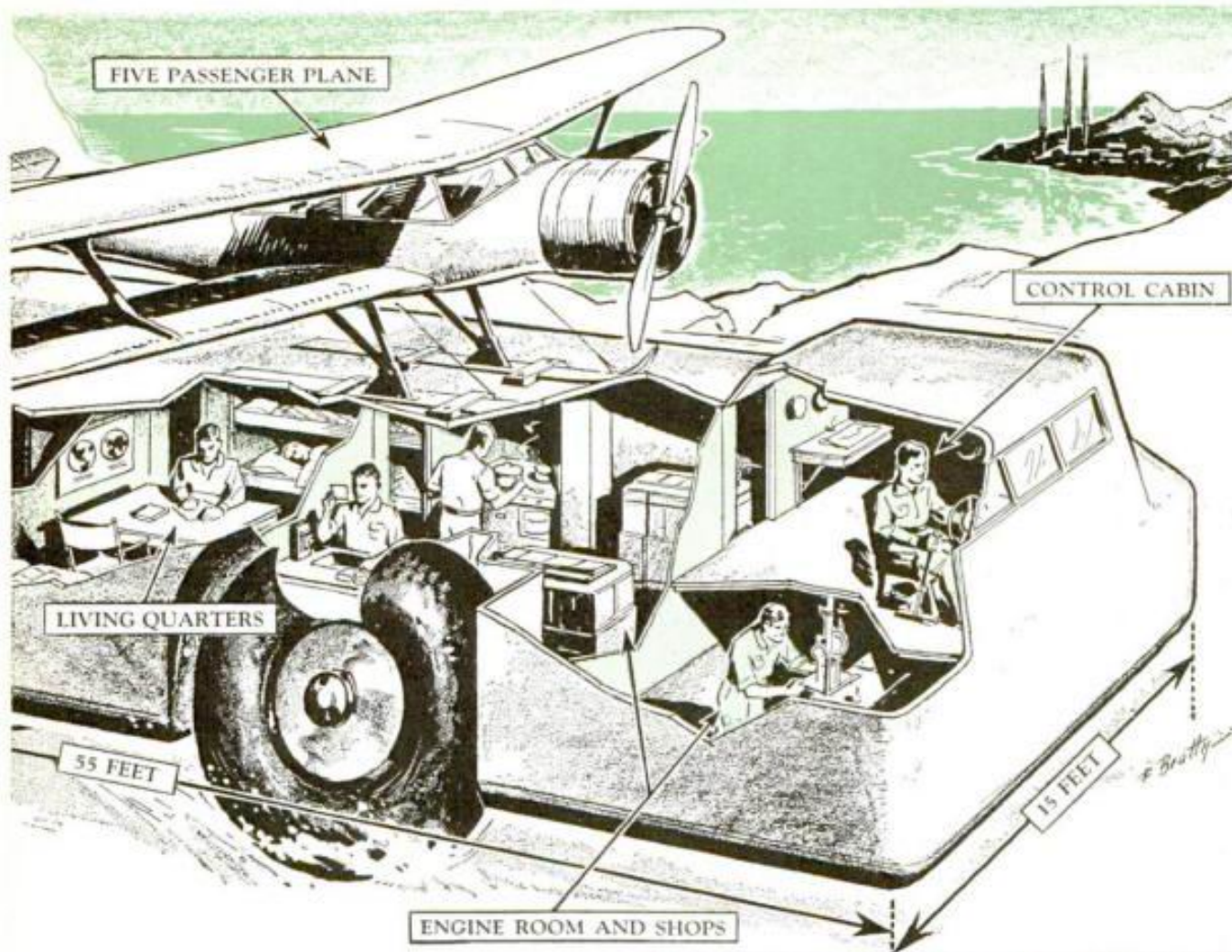
Here's how the snow cruiser will cross a crevasse in polar ice fields. At top the model approaches the "abyss"; as front wheels drop into it, they are retracted and nose of cruiser slides on ice beyond while rear wheels furnish power. When front wheels reach opposite side they furnish traction and rear wheels are drawn up, cruiser sliding on tail. In bottom picture wheels are in normal position and the big bus proceeds on way



IN A Diesel monster that can climb the polar mountains and slither across giant crevasses, four American scientists will spend the coming Antarctic summer exploring the bottom of the world. Fueled and provisioned for a year "on its own," the Antarctic Snow Cruiser designed by the staff of the Research Foundation of Armour Institute of Technology, Chicago, under direction of Dr. Thomas C. Poulter, will carry on its back a five-seat cabin biplane to be used for mapping and exploring a 600-mile strip across Antarctica, with the cruiser as its moving base. Scientific director of the Foundation, Dr. Poulter was second in command of the Byrd Antarctic Expedition II, when he conceived the idea of the snow

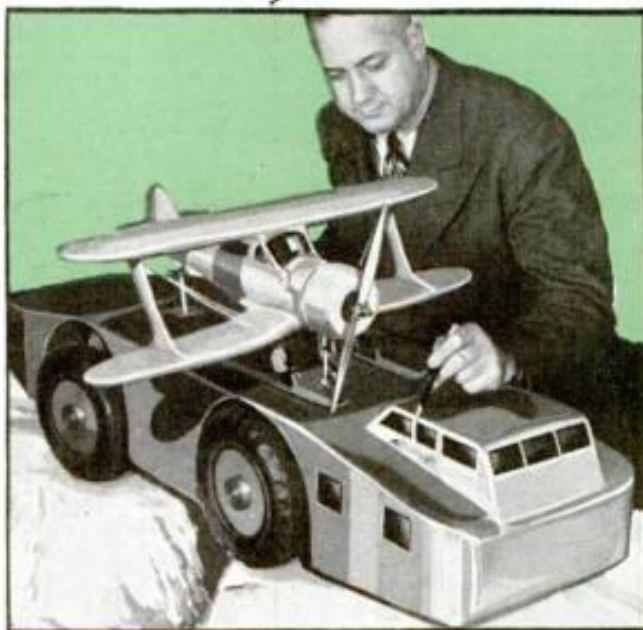
33rd. Federal
and Dearborn
Chicago

to EXPLORE ANTARCTIC



cruiser, and he will be in charge of it during the forthcoming government expedition. Fifty-five feet long and fifteen feet wide, the cruiser will have four wheels, each inclosing an electric motor, wearing pneumatic tires ten feet in diameter and a yard wide. Two 200-horsepower Diesel engines directly connected to generators furnish power for driving, for radio, electric stoves, heat and the machine shop. Flexible controls permit the operator to direct the power of one or both engines to any combination of one, two, three or four wheels. Each wheel is independently adjustable vertically four feet so that the huge "bus" can ride high above the snowdrifts or slide on its undersurface. Reaching a crevasse as wide as fifteen feet, the cruiser will push its nose across until the front wheels are on the brink

(Continued to page 151A)



Cutaway drawing at top shows arrangement of expedition's traveling base; notice that kitchen, just aft of engine room, doubles as photo darkroom. Below, Dr. Poulter with a model of the snow cruiser he conceived

Russia's 'Unbeatable' MiG-23

HOW IT WORKS:
Football's Instant
Replay Page 108

POPULAR MECHANICS

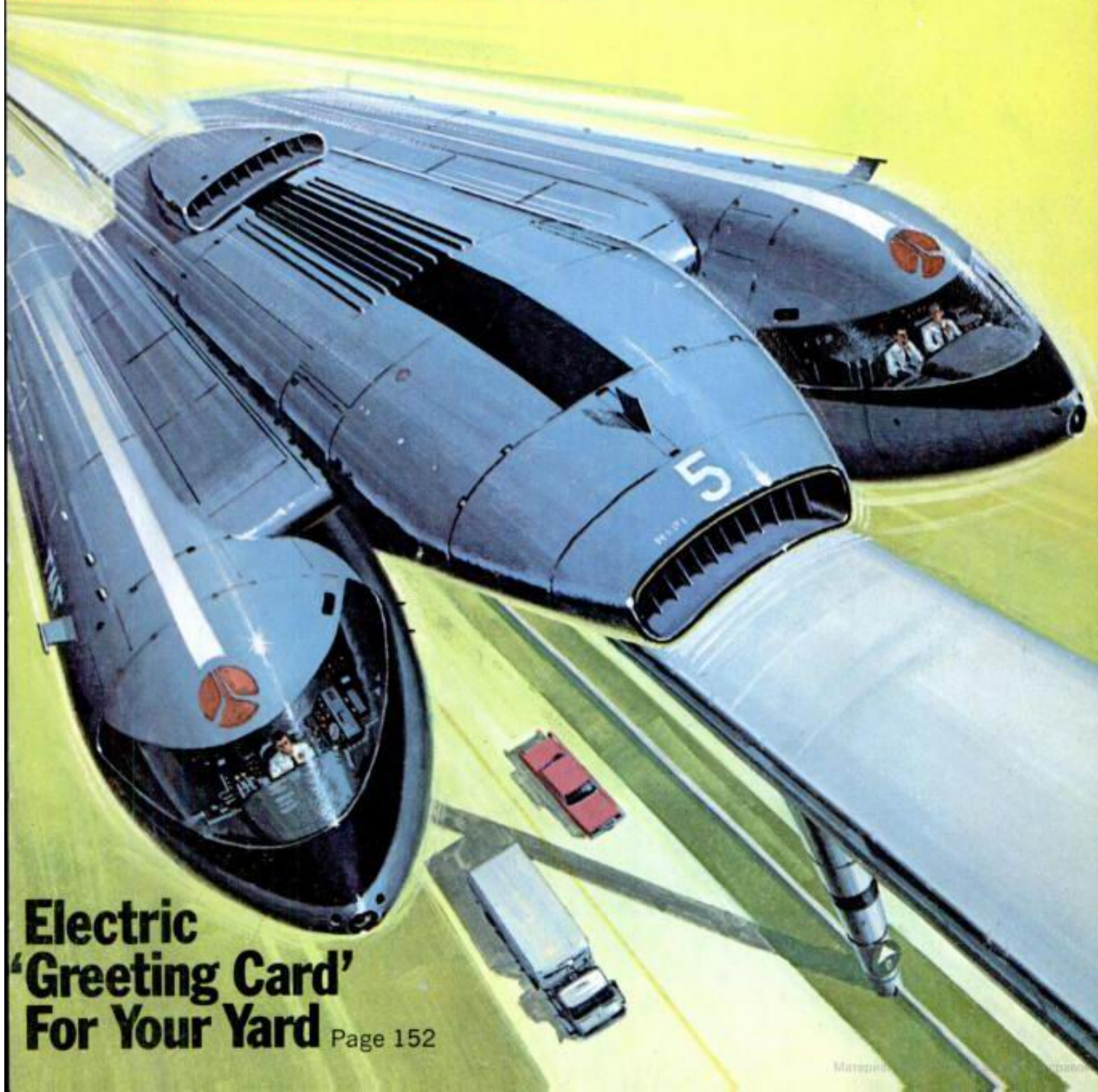
NOV. 1971
50 CENTS

Snowmobile Ordeal at 10,000 Feet

Eyewitness account of a tragedy that almost wiped out two Viking linemen

Page 84

300-MPH MONORAIL Page 81



Electric 'Greeting Card' For Your Yard

Page 152

300 MPH Monorail... Started With a Broomstick

Tri-Mono-Trans was designed for a child. But it's the right answer for every adult ever caught in a traffic jam

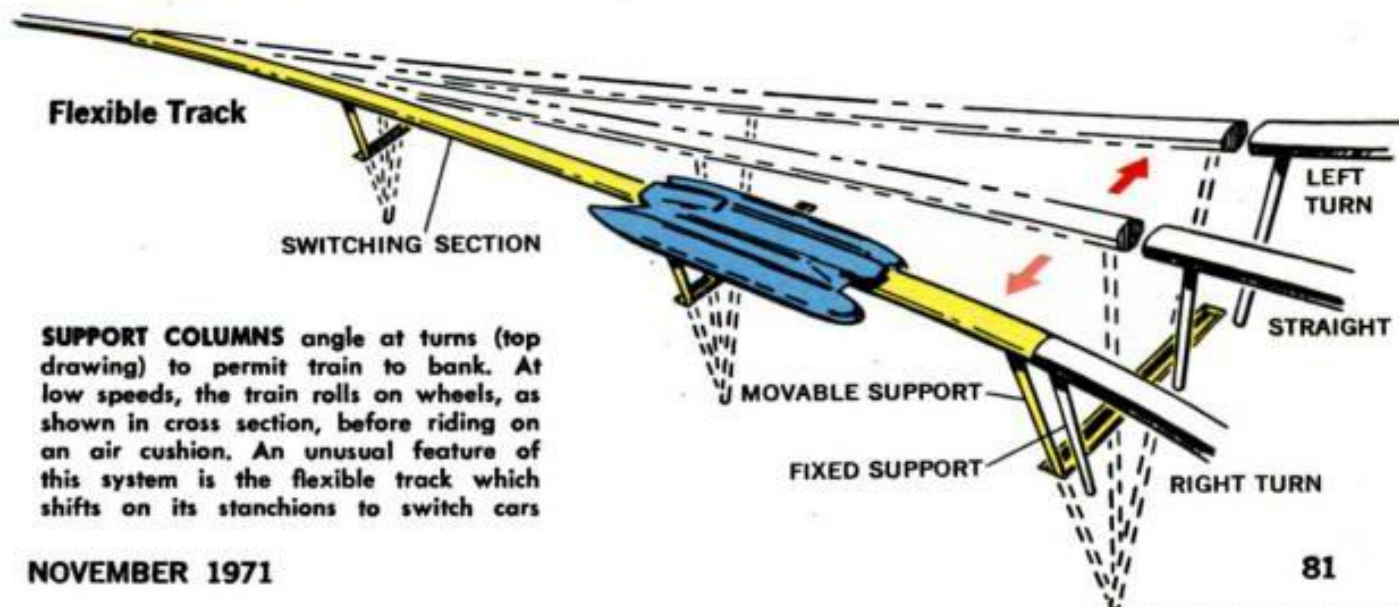
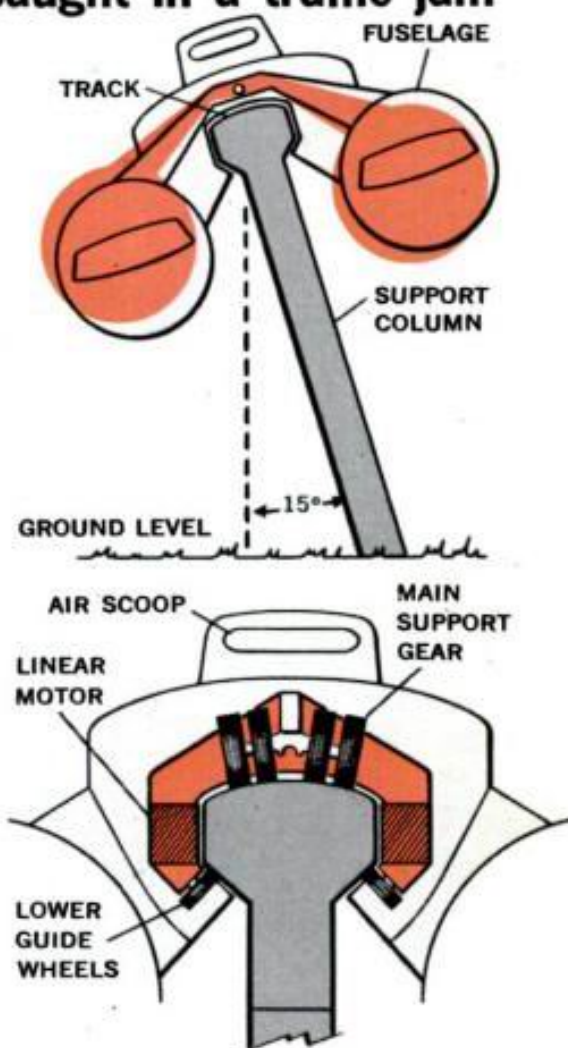
By MIKE LAMM, West Coast Editor

IT BEGAN AS A TOY—a possible replacement for the popular electric train set. It was a futuristic monorail that could run from room to room.

Marty Trent, who developed the idea, is like most who tinker with toys. He dreams of coming up with another "Hula Hoop" or "Hot Wheels" to captivate the children's world. What the 44-year-old project engineer finally did create is something that might be a hit in the adult world instead.

His toy monorail turned into a design for a 300-mph rapid transit system. (It is one of several being investigated as a possible answer to mass transit problems, particularly for interurban movement.)

Eight years ago Trent put together a broom-and-stick-and-molding-strip mockup of the toy and showed it to his project manager at North American Rockwell in Los Angeles. Howard Evans was impressed and suggested Trent work up a full-scale proposal. Then the company became interested and ordered a feasibility study. Out of it came the Tri-Mono-Trans System. What



SUPPORT COLUMNS angle at turns (top drawing) to permit train to bank. At low speeds, the train rolls on wheels, as shown in cross section, before riding on an air cushion. An unusual feature of this system is the flexible track which shifts on its stanchions to switch cars

300 MPH Monorail...



made the "toy" so impressive were design features different from other monorail systems.

Most systems have passenger compartments hanging down from the rail. This means supporting structures and rail must be strong, big—and expensive. With such suspended monorails, the gondola swings and sways, which at high speeds causes nausea in riders.

And most monorail gondolas can bank freely only in one direction, away from the support structure. At high

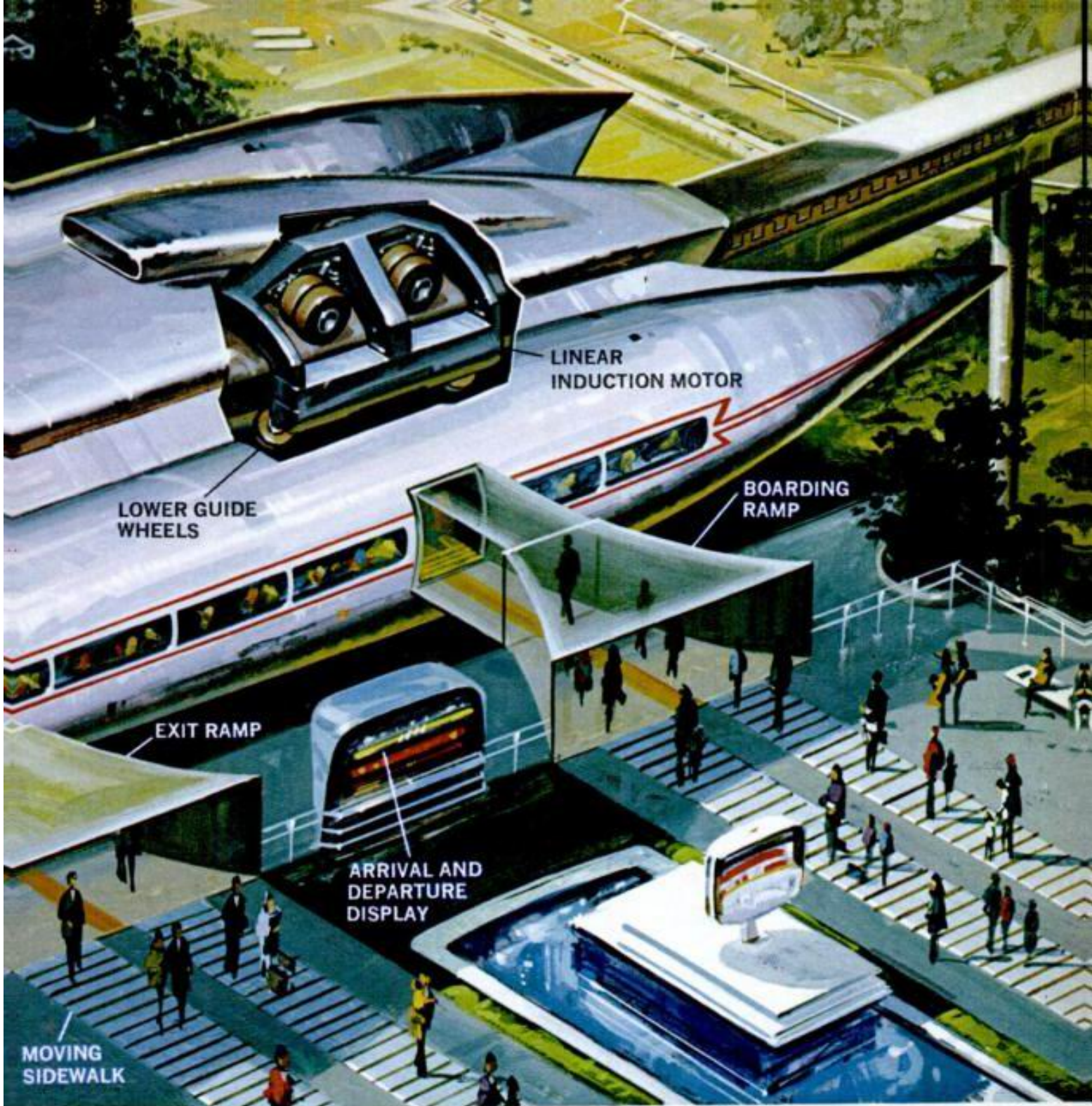
speeds, the support arms have to be cantilevered way out over their base so that banking gondolas don't hit the columns.

Trent's train has passenger fuselages that hang on either side of the track to get a low center of gravity and low roll center.

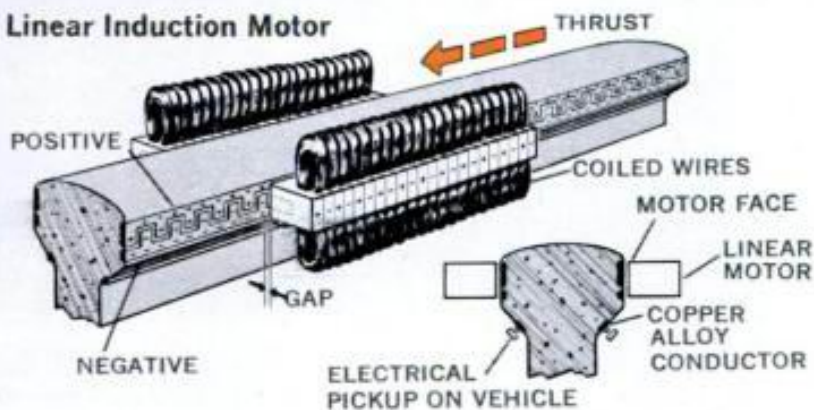
The supporting structure can therefore be relatively light and inexpensive. Stanchions can be cylinders of prestressed concrete, as is used in many bridges. Also the rail would take up

POPULAR MECHANICS

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Linear Induction Motor



5000-HP ELECTRIC MOTOR uses track as armature, while field coils are built into the train. Track and train must not touch. Insulation is provided by rubber wheels and pressurized air cushion

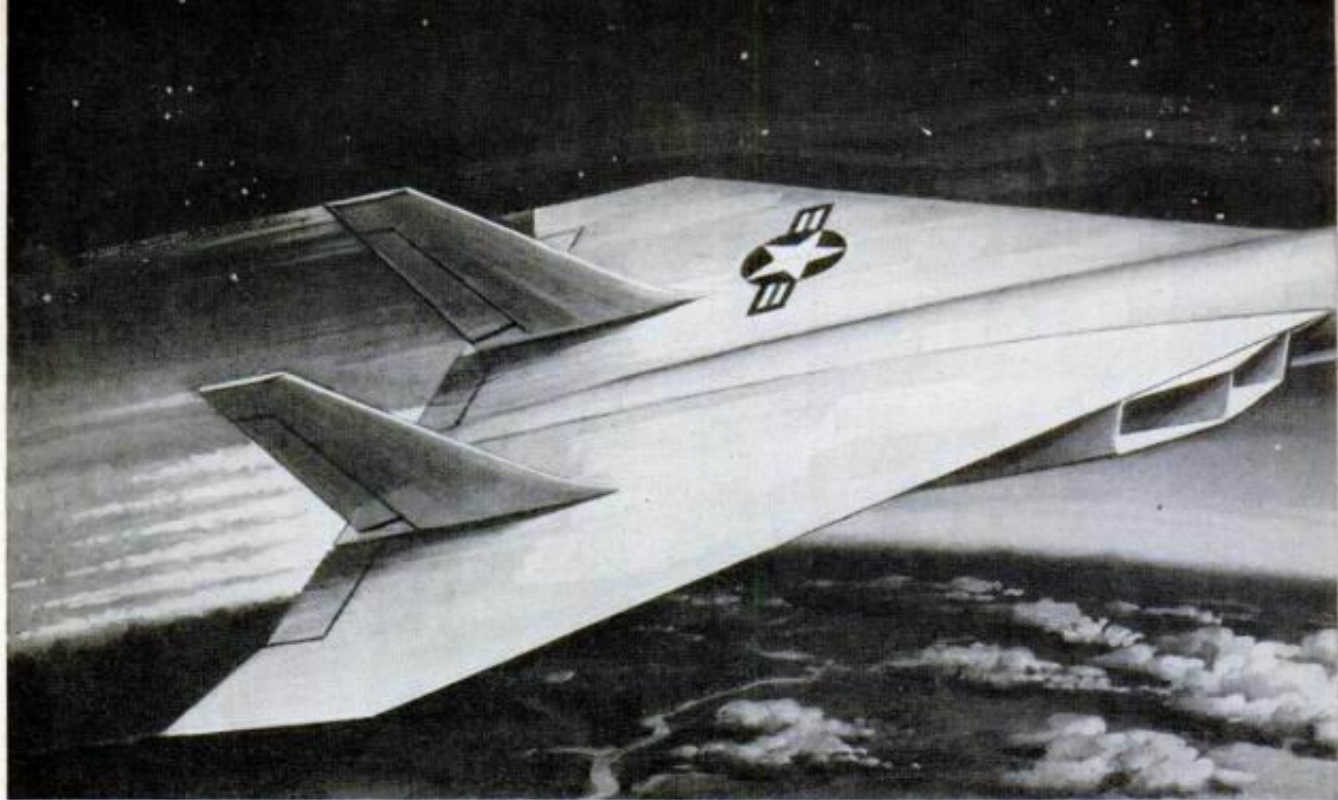
NOVEMBER 1971

little space by being built above existing superhighways.

For switching trains, Trent devised and patented a system in which the long-legged track itself bends—the way prestressed concrete buildings do in the wind.

This same “give” would be used in the monorail track. At switching points, tracks

(Please turn to page 198)



Artist's conception of B-70 Mach 3 bomber; 2000-miles-per-hour passenger planes are based on its design

Ten Years From Now: *Coast to Coast in 90 Minutes*

The jet age is still in diapers, but already our engineers are doodling over paper plans for airliners that will fly at Mach 3 — 2000 miles an hour or better

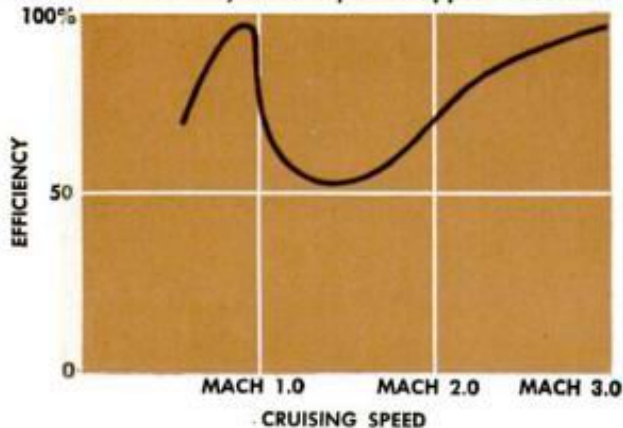
By Thomas E. Stimson, Jr.

OUR BRAND NEW jet airliners are much too slow and it's silly to dawdle across the United States in four and a half hours.

That's the opinion of some of the engineers who designed the present jets.

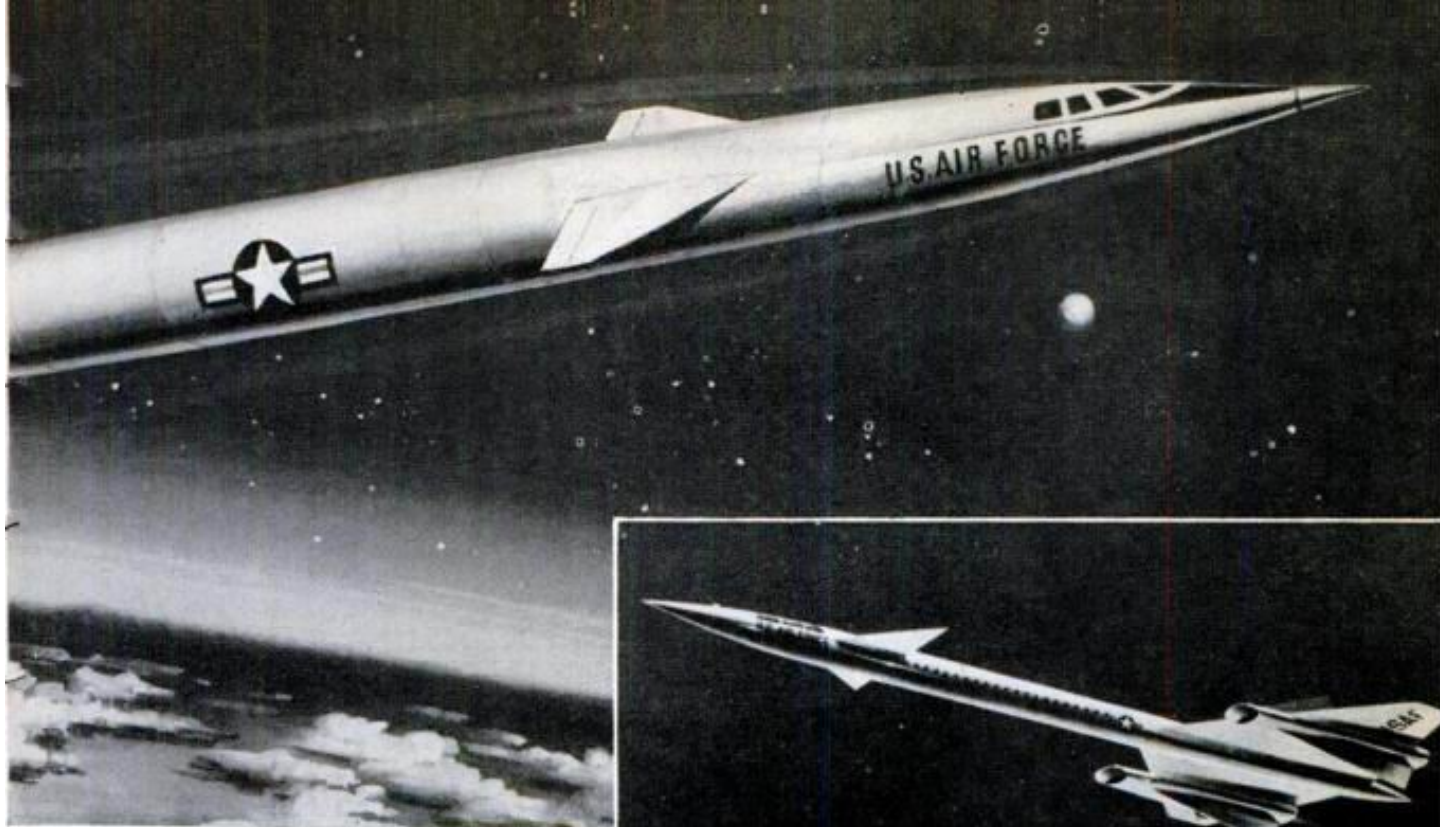
They say that within 10 years we'll be traveling from New York to Los Angeles in 90 minutes, from New York to Paris in a little more than two hours. We'll fly at three times the velocity of sound, a speed that only a few skilled pilots of experimental rocket craft have attained so far.

Propulsive efficiency drops at Mach 1 and climbs to Mach 3. This is why Mach 3 planes appear favorable



R. C. Sebold, Convair engineering vice president, says that in the 1970s a New York business man will be able to leave home half an hour later if his nine o'clock appointment happens to be on the west coast instead of in Manhattan. Leaving New York at 9:30 a.m., he'll fly faster than the sun and reach Los Angeles at eight a.m., a full hour ahead of his appointment time.

Engineers at Boeing, Douglas, Lockheed, North American Aviation and Convair have been spending hundreds of thousands of dollars in research on the next generation of airliners.

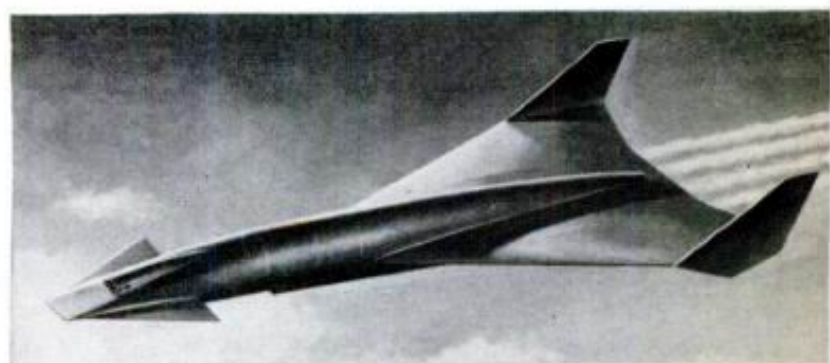
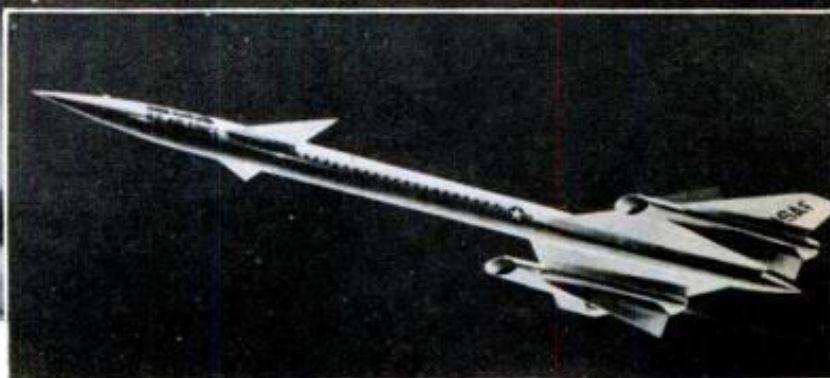


These drawings show varying designs for future 2000-mile-per-hour airliner. From top to bottom are designs of Air Force's Air Research and Development Command, Lockheed, Convair and Rocketdyne Division of North American Aviation. Latter firm would use both rocket and jet power for take-off and climb, and jet power alone for cruise

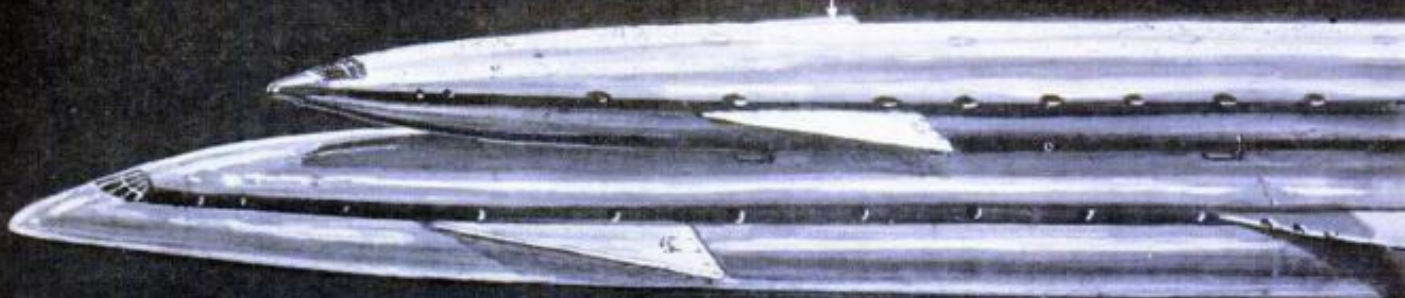
Hundreds of "paper airplanes" have been painstakingly designed and exhaustively analyzed. Scores of models have been flown in wind tunnels, and numerous mock-ups of structures have been built and studied.

Lumping their conclusions together, here's what the engineers foresee: A 75 to 150-passenger transport having a long slender fuselage with a delta-shaped wing at the rear. Another version calls for a long slender shape almost identical with the airplane that you fold from a piece of paper for throwing across the room. In this case the narrow triangular wing extends along the fuselage almost to the nose. Either shape probably would have drooped wingtips and a small canard airfoil near the nose that will serve as elevators and trim surfaces. The plane will have a range of 3500 miles and will cruise most of the way at 2000 miles per hour, some 14 miles above the earth's surface.

On many trips the plane will be in the air for so short a time that its captain may call for landing instructions at his destination before



FOREPLANES ALLOW FOR REAR SLIP OF
AERODYNAMIC CENTER AT SUPERSONIC SPEEDS



HIGH-ALTITUDE MACH 7 AIRLINER (UPPER COMPONENT)
WOULD WEIGH APPROXIMATELY 160,000 POUNDS
AND CARRY 100-130 PASSENGERS. IT
WOULD BE CARRIED BY LOWER COMPONENT
TO ABOUT 90,000 FT. BEFORE RELEASE

RAPID-CLIMB LIFT-AIRCRAFT WOULD WEIGH
APPROXIMATELY 240,000 POUNDS

BRITISH SHOOT FOR MACH 7

HEIGHT
(FT.)

140,000 —
130,000 —
120,000 —
110,000 —
100,000 —
90,000 —
80,000 —
70,000 —
60,000 —
50,000 —
40,000 —
30,000 —
20,000 —
10,000 —

OPERATIONAL HEIGHT IS APPROXIMATELY 130,000-140,000 FT.

PASSENGER LINER CLIMBS TO OPERATIONAL HEIGHT

PRESENT-DAY TRANS-ATLANTIC JET AIRLINERS
OPERATE AT 28,000-33,000 FT., PISTON-ENGINE
AIRLINERS AT ABOUT 20,000-25,000 FT.

PIGGYBACK AIRCRAFT
CLIMBS FAST

TWO PLANES SEPARATE AT 90,000 FT.

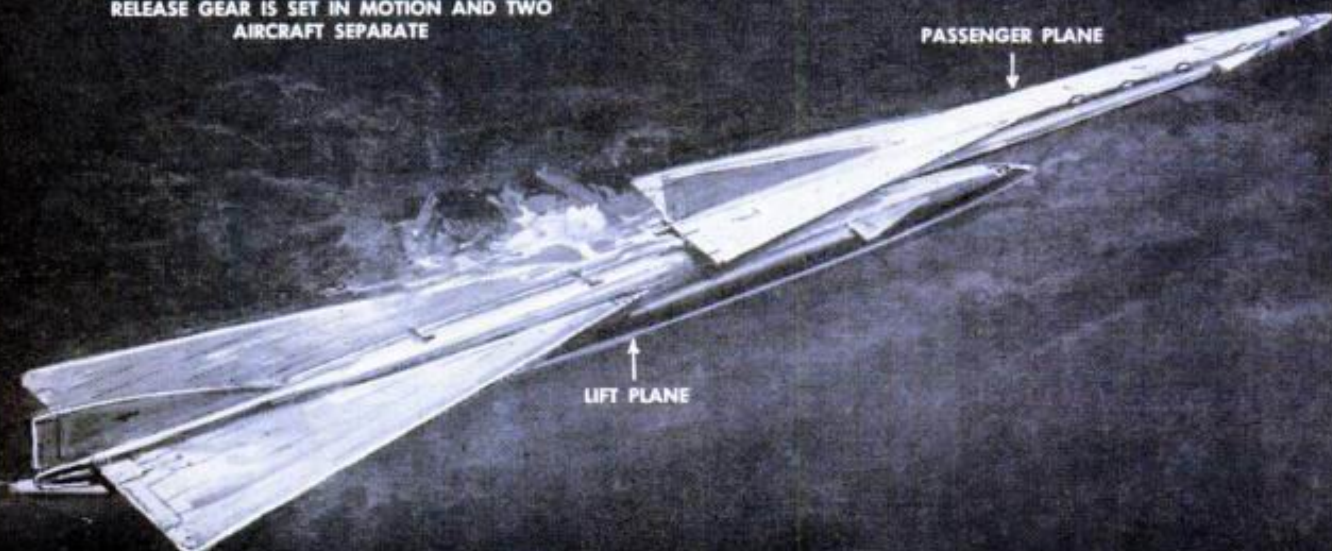
LIFT-AIRCRAFT TURNS AWAY AFTER RELEASE

BACK AT BASE, LIFT-AIRCRAFT PREPARES TO TRANSPORT ANOTHER PLANE

AFTER LIFT-AIRCRAFT (LOWER COMPONENT)
REACHES 90,000 FT., ITS RAMJET ENGINES
ARE SWITCHED ON AND, AT SIGNAL FROM CAPTAIN,
RELEASE GEAR IS SET IN MOTION AND TWO
AIRCRAFT SEPARATE

PASSENGER PLANE

LIFT PLANE



ENGINES BURIED IN WING STRUCTURE

POWER PROVIDED BY HYDROCARBON RAMJETS
FOR MAIN PROPULSION, WITH AUXILIARY
TURBOJETS FOR LANDING CONTROL

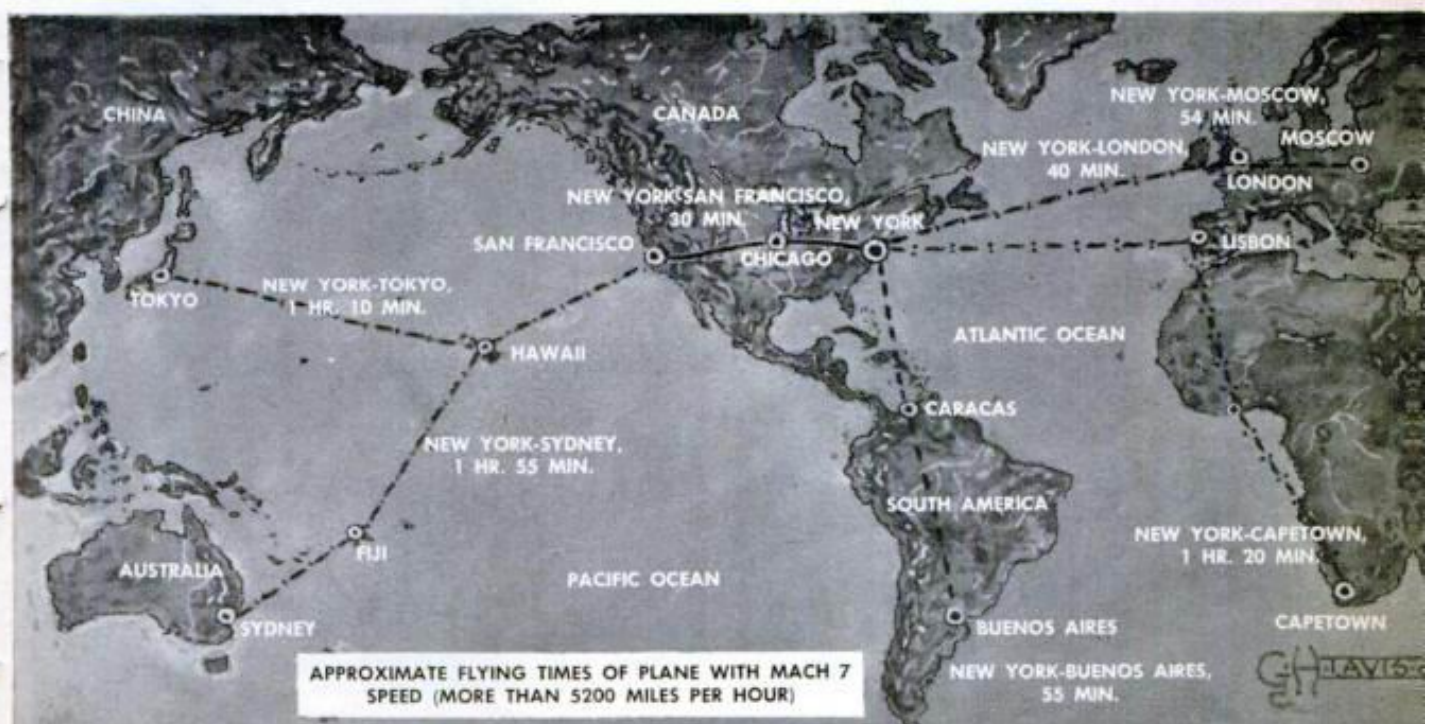
SLIM DELTA WING TO PROVIDE SATISFACTORY
LIFT/DRAG RATIO

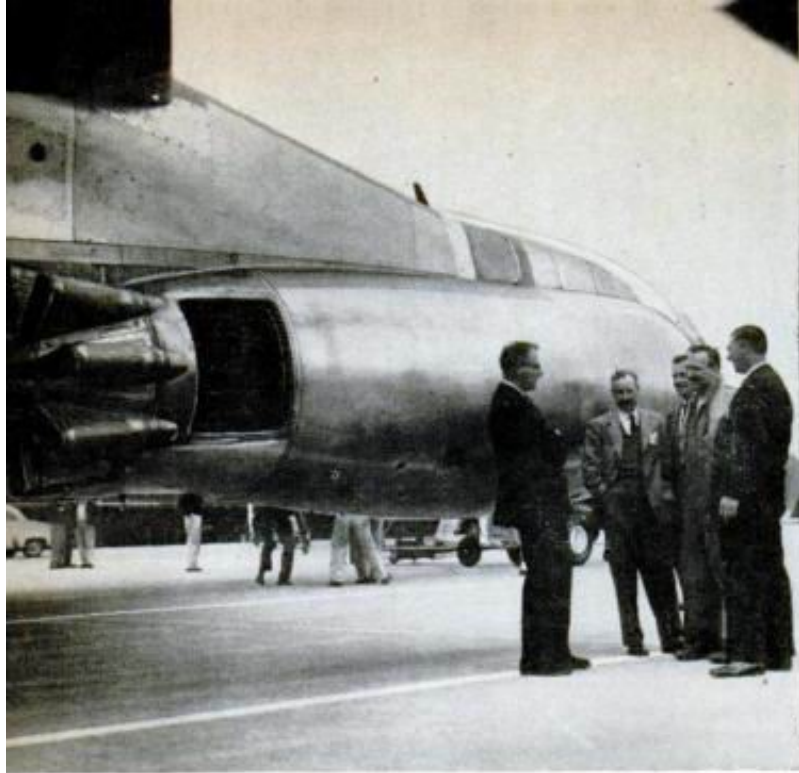
EXCLUSIVELY FOR *Popular Mechanics*, British artist G. H. Davis created this design of a pickaback airliner based on an idea of Dr. R. R. Jamison, British aeronautical engineer, who envisions a plane that would be capable of Mach 7 speed, or more than 5200 miles per hour. Davis based his conception on existing hypothetical plans for supersonic aircraft.

DESCENT OF MACH 7 AIRLINER WOULD START HUNDREDS
OF MILES AWAY SO GLIDE PATH WOULD NOT BE TOO
ACUTE, AND SET UP FRICTIONAL HEATING WHEN
REACHING AND PASSING THROUGH DENSER ATMOSPHERE

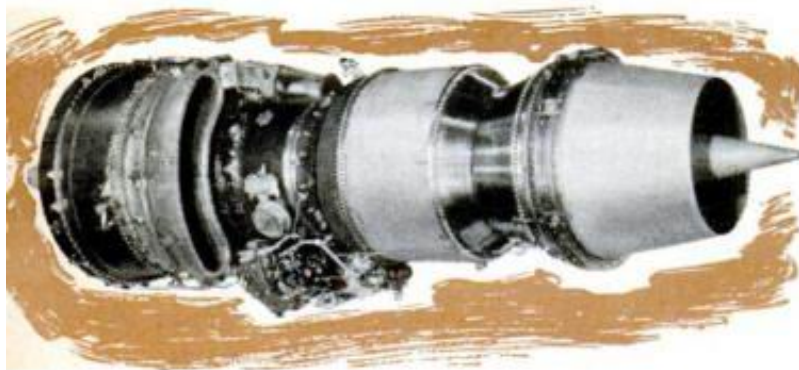
AT LOWER ALTITUDES, AUXILIARY TURBOJET
MOTORS WOULD BE USED TO AID LANDING CONTROL

HEIGHT (FT.)	ATMOSPHERIC PRESSURE
130,000	.093 IN. "
120,000	.139 IN. "
110,000	.211 IN. "
MERCURY	
100,000	.326 IN. "
90,000	.51 IN. "
80,000	.82 IN. "
70,000	1.32 IN. "
60,000	2.13 IN. "
50,000	3.45 IN. "
40,000	5.55 IN. "
30,000	8.90 IN. "
20,000	13.78 IN. "
10,000	20.59 IN. "





Turbofan engine on Boeing 707 has wide ducting to let extra air flow around engine. Turbofan, below, shows duct near end



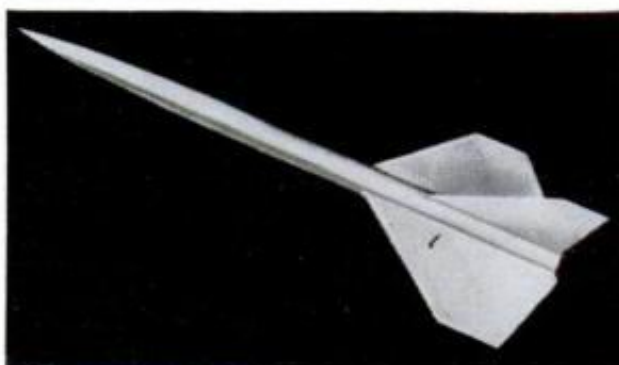
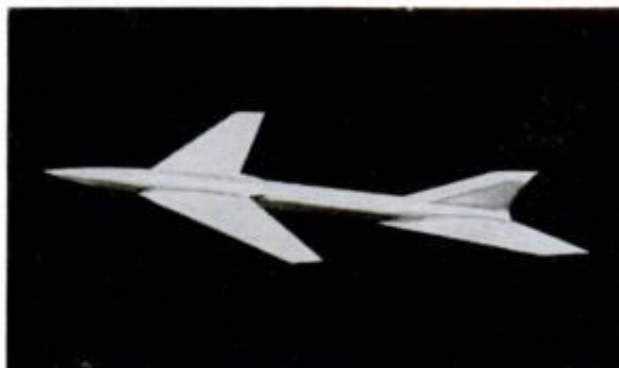
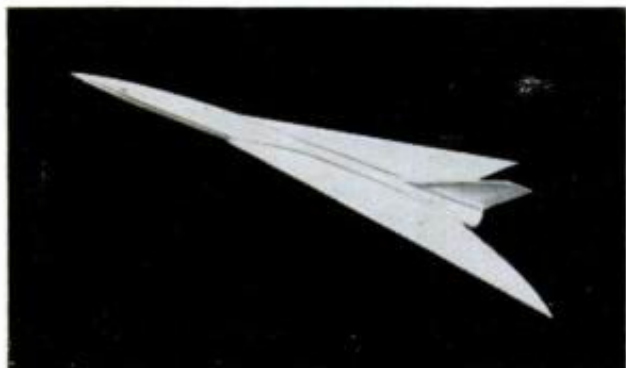
he takes off. And instead of handling the controls it's more likely that the crew will simply monitor the automatic devices that do all or most of the actual flying.

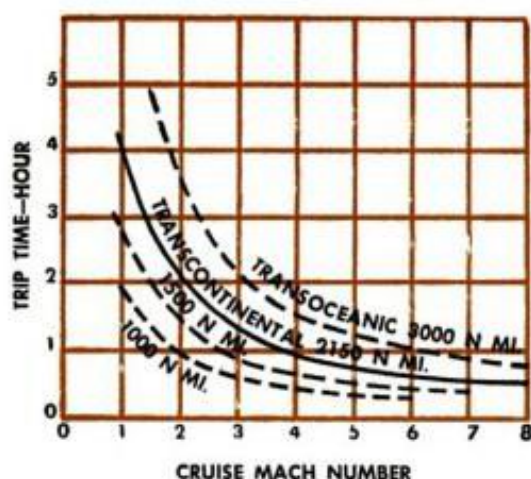
"The pilot may elect to accomplish his climb by pre-programmed tape operating through the autopilot," says M. L. Pennell, chief engineer, Boeing transport division. "Navigational equipment may include digital computers that avoid the necessity of the pilot solving a mathematical problem to arrive at his position, which is changing about 30 miles every minute. All messages to the airplane could be received on the airborne radio-teletype. Voice reporting and manual note-taking are impractical at Mach 3 speeds.

"The effect of headwinds is quite small because of the short mission time. From Paris to New York, for instance, a 50 mile per hour headwind would increase the trip time by only three minutes."

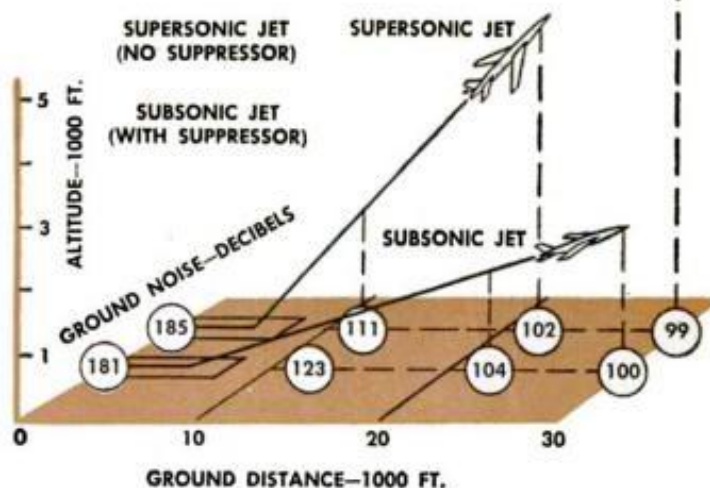
Another possibility is an inertial-guidance system in the airliner to control its flight. This type of guidance was developed first for missiles. In an airliner it could be connected to a visual display in the cockpit in the form of a map on which a moving dot of light would constantly show the plane's position.

WING AND BODY ARRANGEMENTS





Relating speed to trip time, graph indicates how trip time flattens out beyond Mach 3

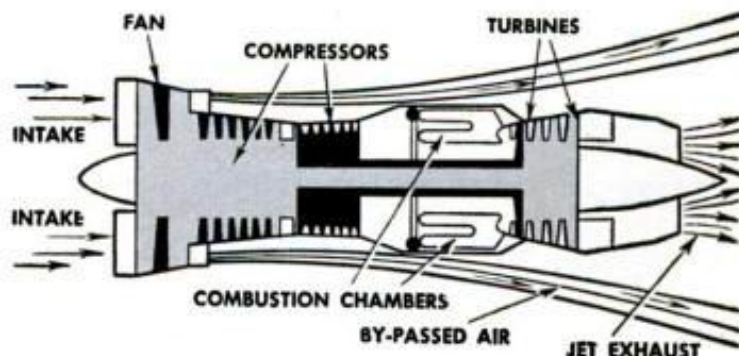


Lockheed drawing shows climb paths of supersonic and subsonic jets from airport, also noise in decibels created on ground

Passengers will find little difference between the Mach 3 airliners and the present jets aside from a few novel details. During the climb to altitude they'll prefer to remain in their seats, for the planes will climb at such a steep angle that walking is difficult. And it may be that in place of the windows they'll have flat-plate TV for entertainment. At 70,000 feet they wouldn't be able to see much anyway, and windows are a real headache to structural engineers.

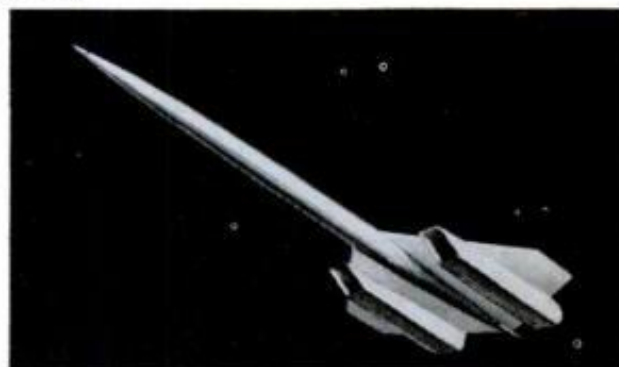
Unless a passenger has a technical background he'll find it hard

(Continued to page 251)



This drawing of Pratt & Whitney's JT3D turbofan engine shows how fan section was added to standard jet engine. The addition better air performance, boosts power and is economical

POWERPLANT INSTALLATION



SEE THE NEW CARS IN COLOR

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DEC. 1958 **SIX-MINUTE RIDE INTO SPACE** 35 CENTS

POPULAR MECHANICS MAGAZINE

WRITTEN SO YOU CAN UNDERSTAND IT

PRINTED IN BRITAIN NO. 40476

SEE US At OFF

Atomic Submarine Tanker—Page 102

WHAT WE'RE DOING ABOUT AIR SAFETY
PM Interviews The President's Adviser on Aviation

The Greatest Magic Illusions of All Time

SHOWCASE of TOOLS: The Electric Drill

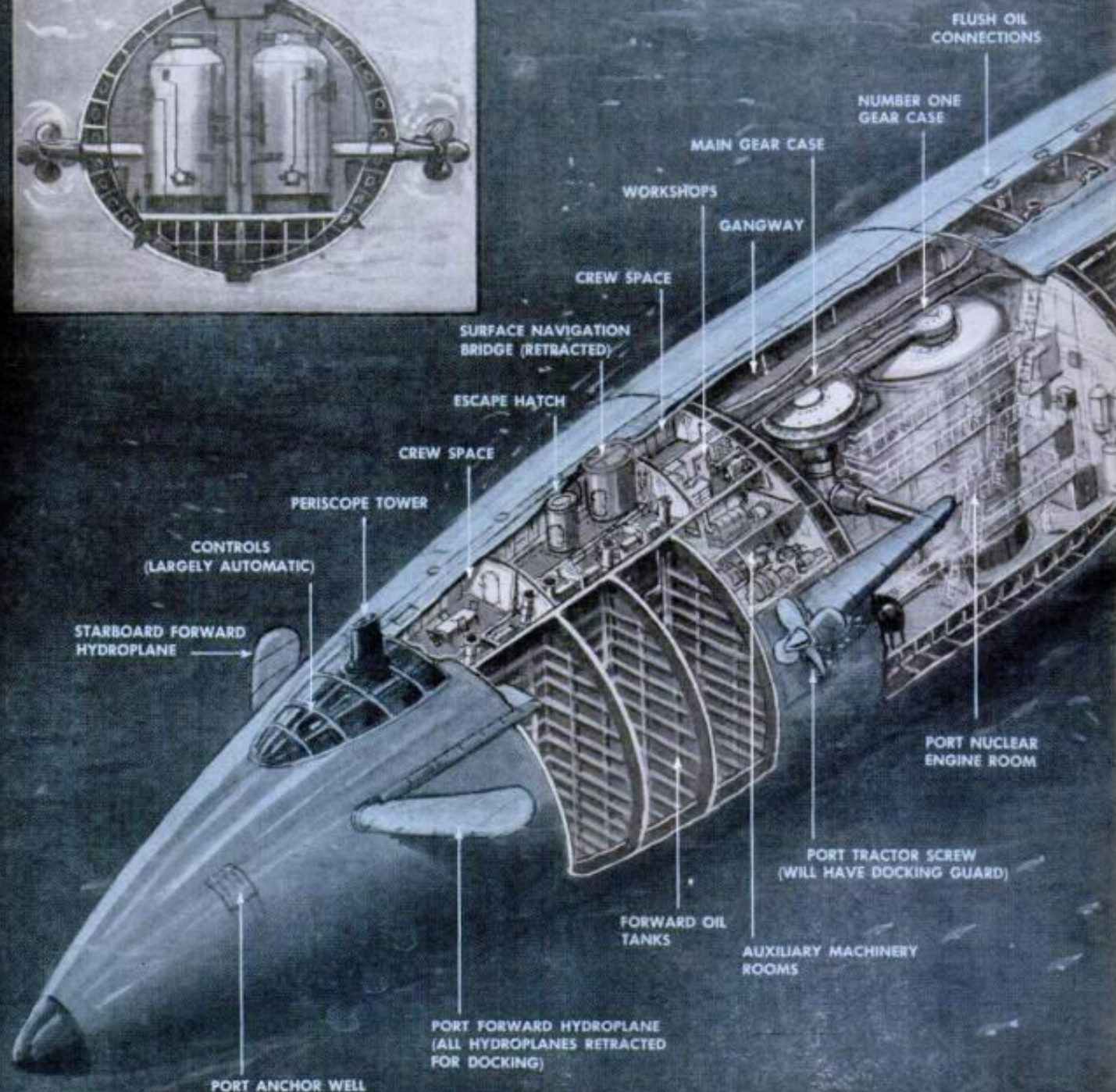
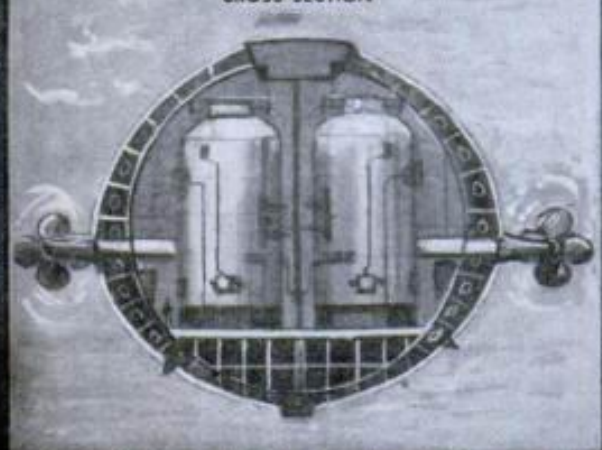
TOOLS TO BUY FOR CHRISTMAS



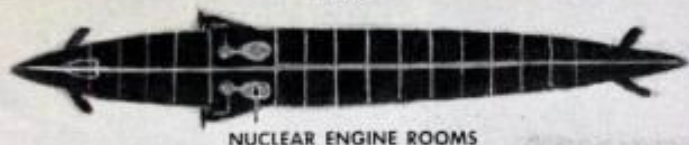
THE PROPOSED SUBMARINE TANKER COMPARED TO SCALE WITH THE U. S. SUBMARINES *NAUTILUS* AND *TRITON*



CROSS SECTION



PLAN



NUCLEAR ENGINE ROOMS

STARBOARD AFTER HYDROPLANE

UPPER STEERING RUDDER

LOWER RUDDER

PORT AFTER HYDROPLANE

UPPER DECK

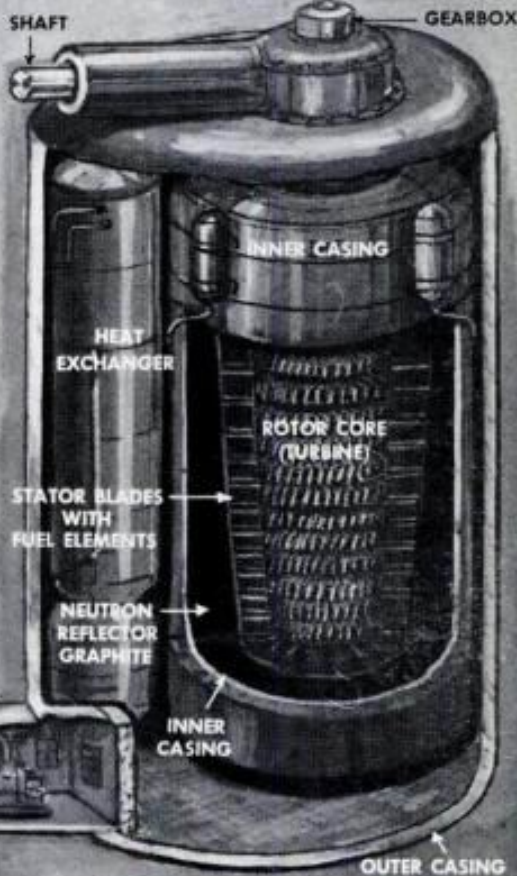
OIL VALVES
GANGWAY

MAIN OIL TANKS
(CAPACITY 80,000 TONS)

SADDLE TANKS
(FOR BUOYANCY CONTROL)

TURBOGENERATOR FOR PRODUCING
AUXILIARY POWER

A SUGGESTED IDEA FOR A REVOLUTIONARY NUCLEAR POWER PLANT. THE HEAT GENERATED IN THE STATOR BLADES WARMS PRESSURIZED GAS (CARBON DIOXIDE) WHICH RISES BY CONVECTION AND ROTATES THE TURBINE



GIANT ATOMIC SUB TANKER

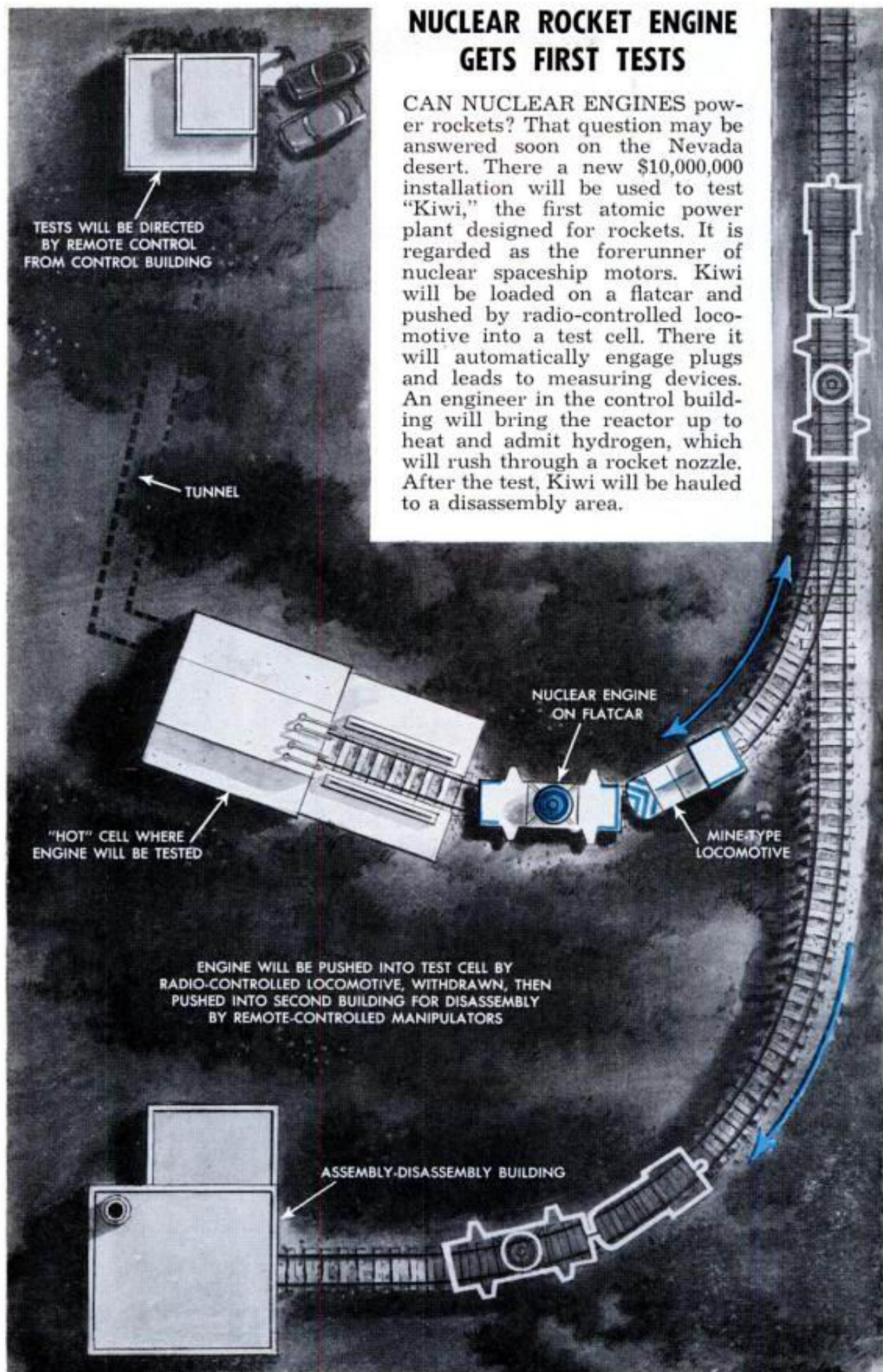
Text and Drawing
by G. H. Davis,
Noted British Artist

USING A NEW TYPE of nuclear power plant, a submarine tanker being designed by Britain's Mitchell Engineering Company would be capable of carrying 80,000 tons of oil at speeds far in excess of any submarine yet built. Model tests of the vessel have been made in the 600-foot experimental tank of Saunders-Roe Limited, famous aircraft and ship-builders. Details of the nuclear power plant have been a jealously guarded secret, but it will not use the present

round-about method of producing power from the atom. One suggestion is that power may be produced more directly by incorporating fuel elements in the fixed blades of a turbine engine. Heat from the blades would cause pressurized gas to rise by convection, rotating the turbine. It is believed the power plant could drive the tanker at the great speed of 40 to 50 knots. A crew of about 12 men would be sufficient as many of the controls would be automatic. ★ ★ ★

NUCLEAR ROCKET ENGINE GETS FIRST TESTS

CAN NUCLEAR ENGINES power rockets? That question may be answered soon on the Nevada desert. There a new \$10,000,000 installation will be used to test "Kiwi," the first atomic power plant designed for rockets. It is regarded as the forerunner of nuclear spaceship motors. Kiwi will be loaded on a flatcar and pushed by radio-controlled locomotive into a test cell. There it will automatically engage plugs and leads to measuring devices. An engineer in the control building will bring the reactor up to heat and admit hydrogen, which will rush through a rocket nozzle. After the test, Kiwi will be hauled to a disassembly area.





First of a Great New Breed

Slated to start service this winter, Boeing's giant jet will carry more passengers — up to 490 in all — and more cargo than any airliner in history.

By JOHN F. PEARSON, Science Editor

EARLY NEXT YEAR A NEW PLANE WILL ANGLE across the busy sky over Kennedy International Airport. It shouldn't be hard to spot, for it's sure to be the single biggest object cutting through the New York smog. The plane is the Boeing 747, newest and largest airliner in the world, capable of carrying as many as 490 passengers. Sporting the blue and white livery of Pan American, it will be configured to carry 362 and be bound for London and Frankfurt on its first commercial flight.

The 747 is the first of a new breed. It is *not* America's answer to the French-English Concorde or Russia's TU-144, needle-nosed supersonic darts now being tested. Rather, it is a bigger, faster, more stable, more comfortable version of today's subsonic jets.

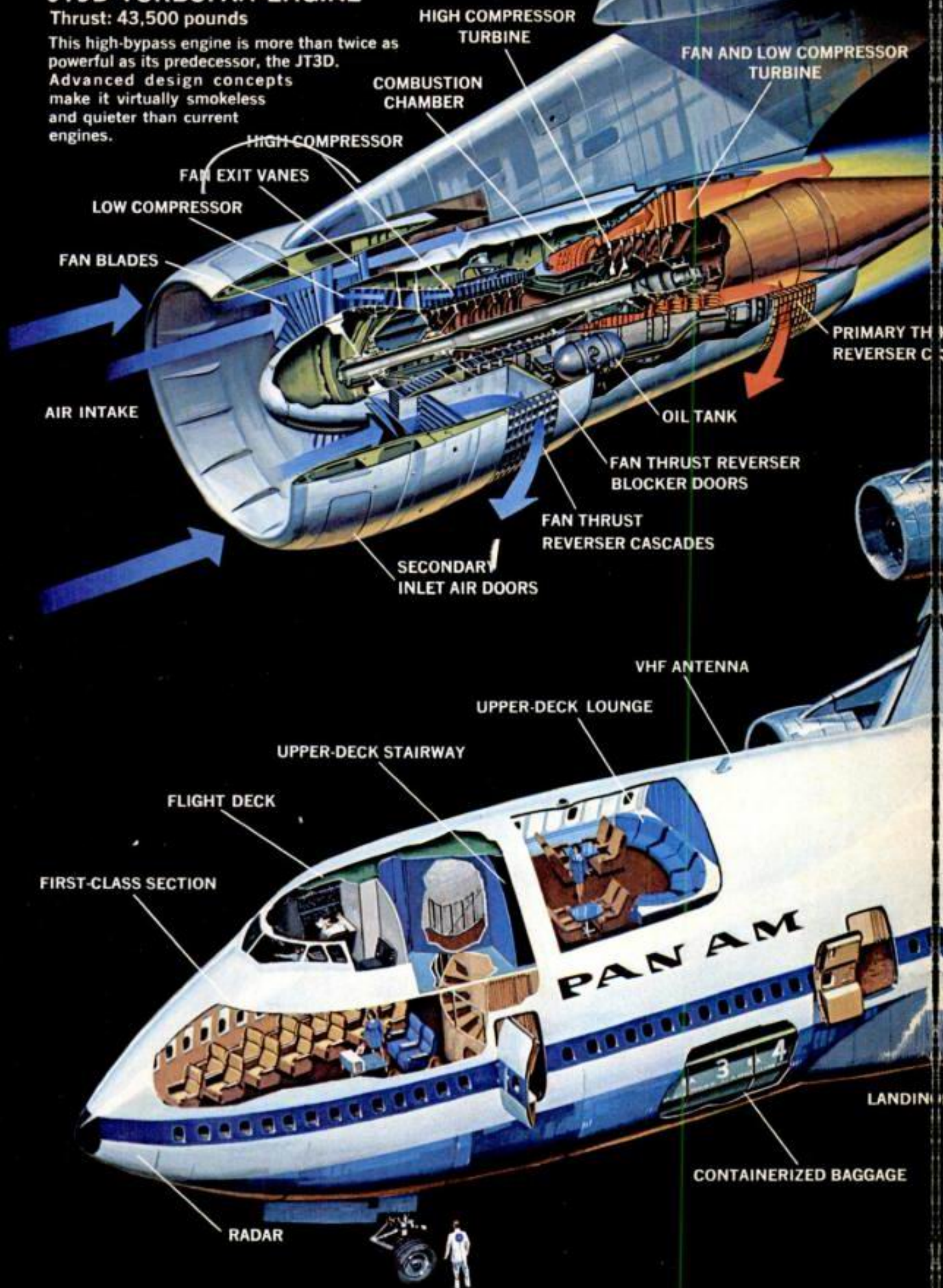
But that ho-hum description doesn't do the 747 justice. It's an exciting plane, even awesome and majestic. That's the impression I came away with after two days of examining test planes and those in various stages of completion at Boeing's huge facility north of Seattle. Stand toward the rear of a 747 and you have to bend your head back to see the top of its tail, which juts as high as a five-story building. You walk under wings that stretch almost 200 feet from tip to tip, and look into engine intakes eight feet in diameter, more than big enough to permit Wilt Chamberlain to stand inside wearing a top hat. The craft is so big and solid-looking that you wonder how it can be supported by anything as insubstantial as air.

But fly it does, and very well. On takeoff you notice that it is quieter than current jets and that the engines are almost smokeless. Despite its bulk, the 747 requires even less takeoff runway—about (*Text continues on page 111*)

PRATT & WHITNEY AIRCRAFT JT9D TURBOFAN ENGINE

Thrust: 43,500 pounds

This high-bypass engine is more than twice as powerful as its predecessor, the JT3D. Advanced design concepts make it virtually smokeless and quieter than current engines.



Art Concept Created for Popular Mechanics by Ed Valigursky, Fred Wolff, Howard Schafer, Roger Metcalf and Peter Trojan.

Материал, защищенный авторским правом

The Boeing 747

WORLD'S LARGEST AIRLINER

THE 747 is the first of a new breed — the giant jets. Though it is designed to carry up to 490 passengers, Pan Am's seating configuration calls for 362. The craft cruises at 625 mph and has a range of more than 5000 miles. It is 231 feet, 4 inches long, has a wingspan of 195 feet, 8 inches, and weighs up to 712,000 pounds at takeoff.

(For more information on the 747 see reverse side.)

PRIMARY EXHAUST
TAIL CONE

RUST
ASCALDES

TRIPLE-SLOTTED FLAPS

ECONOMY SECTION

GALLEYS

ECONOMY SECTION

FLIGHT SPOILER

HIGH SPEED AILERON

G LIGHTS

FLAP-ACTUATING SYSTEM

STANDARD KREUGER FLAP

VARIABLE-CAMBER KREUGER FLAP

AIRESEARCH GT-CP 660 AUXILIARY POWER UNIT

Equivalent to 2000 HP

On ground, it provides power
for all airplane systems.

AIR INLET

TURBINE

COMPRESSOR

GENERATORS

AUXILIARY POWER UNIT

BODY LANDING GEAR
IN STOWED POSITION

WING LANDING GEAR
IN STOWED POSITION

RETRACTION JACK SCREW

BODY LANDING GEAR

OLEO SUSPENSION SYSTEM

WING LANDING GEAR

MULTI-DISC BRAKES

HF ANTENNA

LANDING GEAR

A total of 18 wheels: 2 sets of
4-wheel bogies are attached to
fuselage, 1 set is affixed to each
wing, and 2 wheels support nose.

CONTAINERIZED
CARGO

GROUND SPOILER

OUTBOARD AILERON

VARIABLE-CAMBER KREUGER FLAP



PAN AM FLIGHT INSIGNIA
All 747 Command
Captains will wear these wings.

When Should You 'Fight' a Speeding Ticket? Page 81

POPULAR MECHANICS

SEPT. 1969
50 CENTS

**New Tougher-to-Pick
Door Locks** Page 134

**ABCs of Chassis and
Suspension
Systems**

**Better
Sound
From
Your TV** Page 148

*New Fly-It-Home
Ejection Seat*

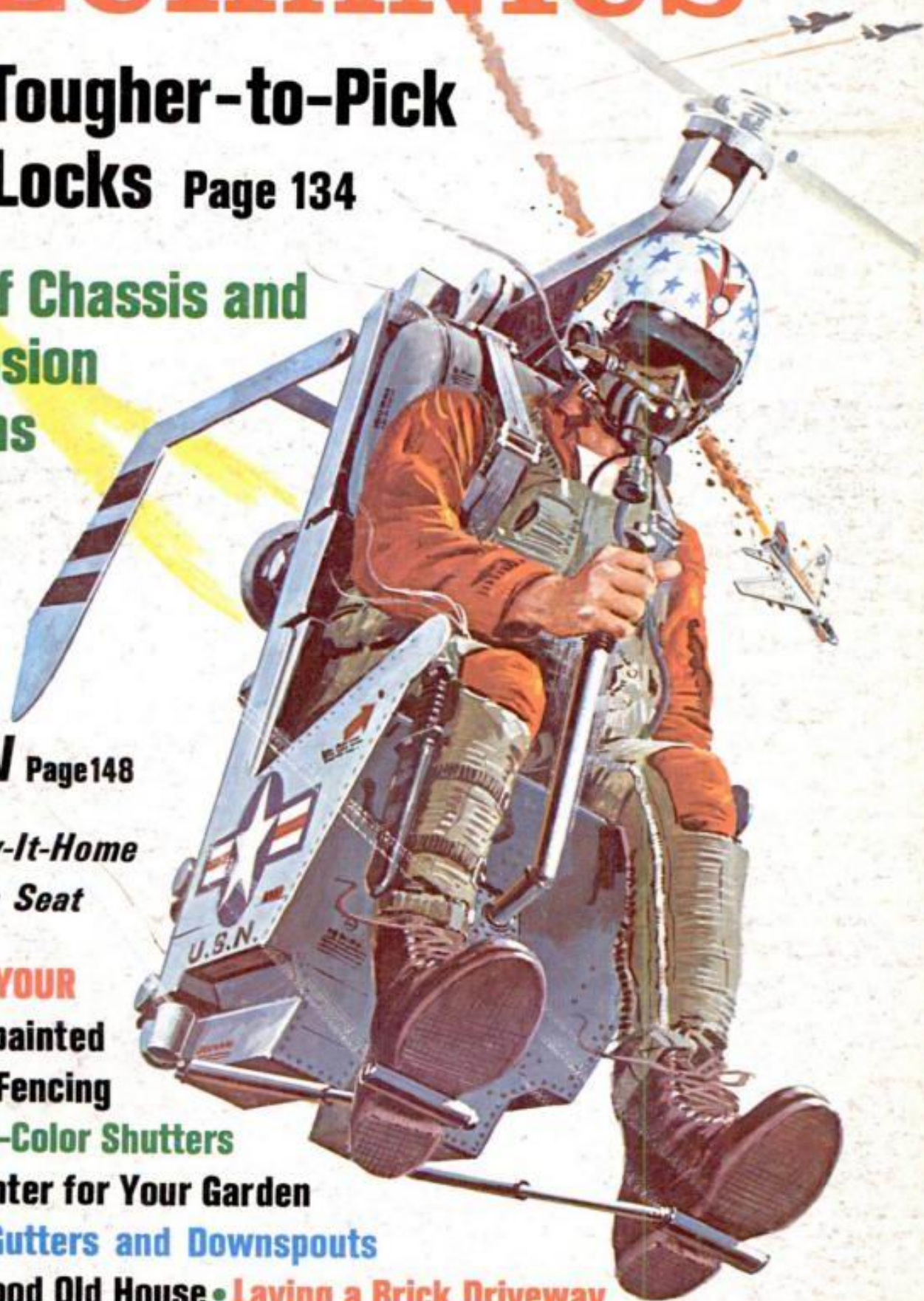
**IDEAS FOR YOUR
HOME:** Prepainted
Aluminum Fencing

Come-With-Color Shutters

A Work Center for Your Garden

Installing Gutters and Downspouts

Buying a Good Old House • Laying a Brick Driveway



① PILOT ROCKETS FREE OF PLANE

DROGUE CHUTE
DEPLOYS

②

ROTOR BLADES
DEPLOY

ENGINE DROPS
FROM NESTED
POSITION

TAIL
ASSEMBLY
UNFOLDS

④

ENGINE STARTS

AUTOROTATING
BLADES

⑤

PARACHUTE

CONTROL
STICK

TURBOFAN
ENGINE

STABILIZERS
IN EXTENDED POSITION

EJECTION
GUIDE ROLLERS

EJECTION
POWER
UNIT

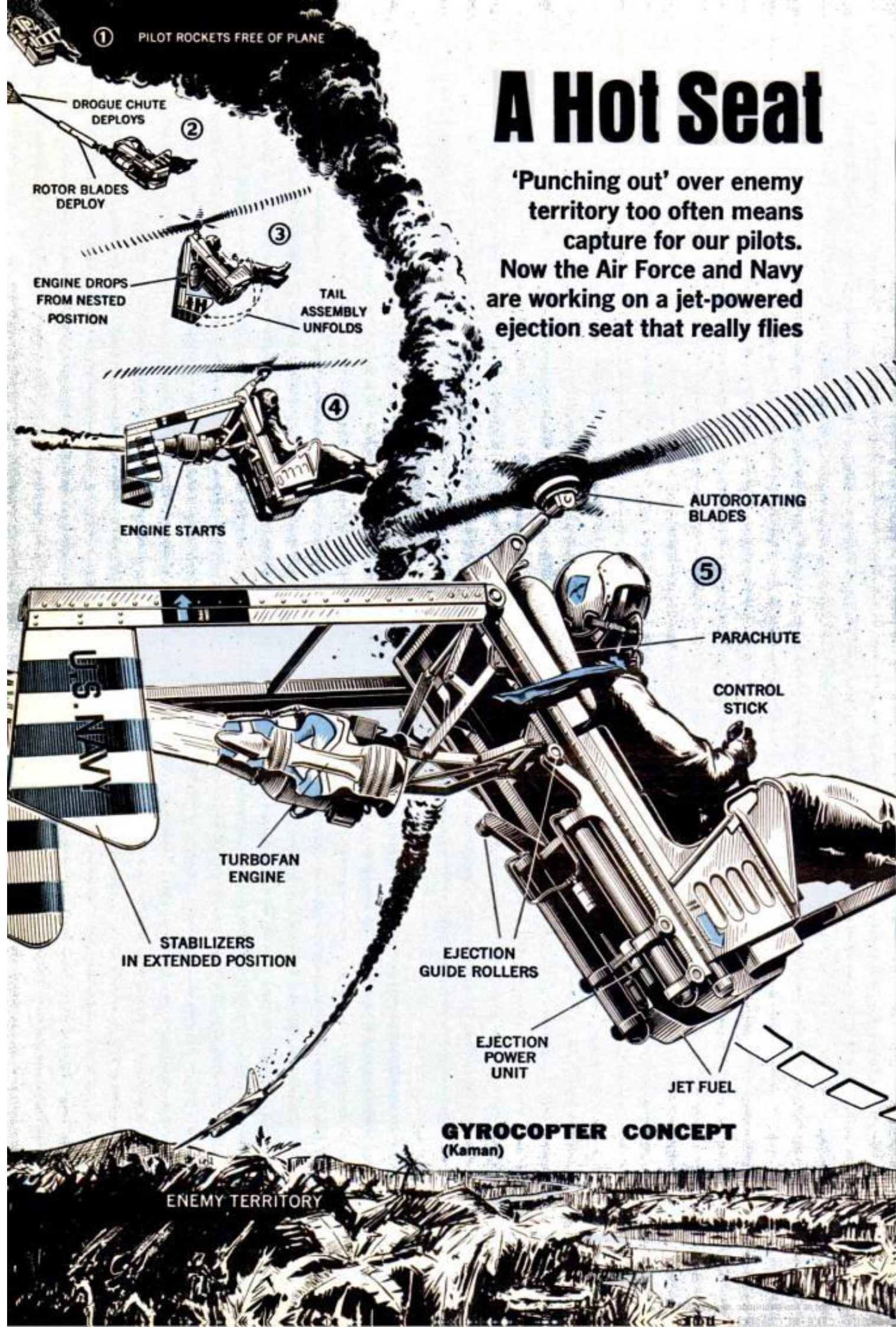
JET FUEL

GYROCOPTER CONCEPT
(Kaman)

ENEMY TERRITORY

A Hot Seat

'Punching out' over enemy territory too often means capture for our pilots. Now the Air Force and Navy are working on a jet-powered ejection seat that really flies



to Bring 'Em Back Alive

By KEVIN V. BROWN

Technical Art Concepts by Fred L. Wolff

THE PILOT LINED UP his jet, nursing the sight onto the designated target. Then he dived in low and fired his missiles, watching them streak out before him. It was a good run and a good hit.

Before he could congratulate himself he heard a *thunk*. Red lights flashed on his instrument panel.

He pushed the mike button. "I've been hit."

The flight leader called back: "I see it. You've got smoke."

"I'm losing fuel pressure. I may have to punch out."

"Try to make it to the coast."

"I can't. My engine just quit."

"Roger," said the flight leader. "We'll try to get a chopper in for you. Good luck."

The other pilots watched as the canopy peeled off the crippled plane. Then the seat, with the pilot in it, rocketed out. When well clear, pilot and seat separated. A parachute billowed, and the pilot floated to the dense jungle—in the heart of Vietcong territory.

His chances of being picked up by helicopter were reasonably good. Air

rescue has become a fine art in Vietnam.

But his chances of falling into enemy hands were even better.

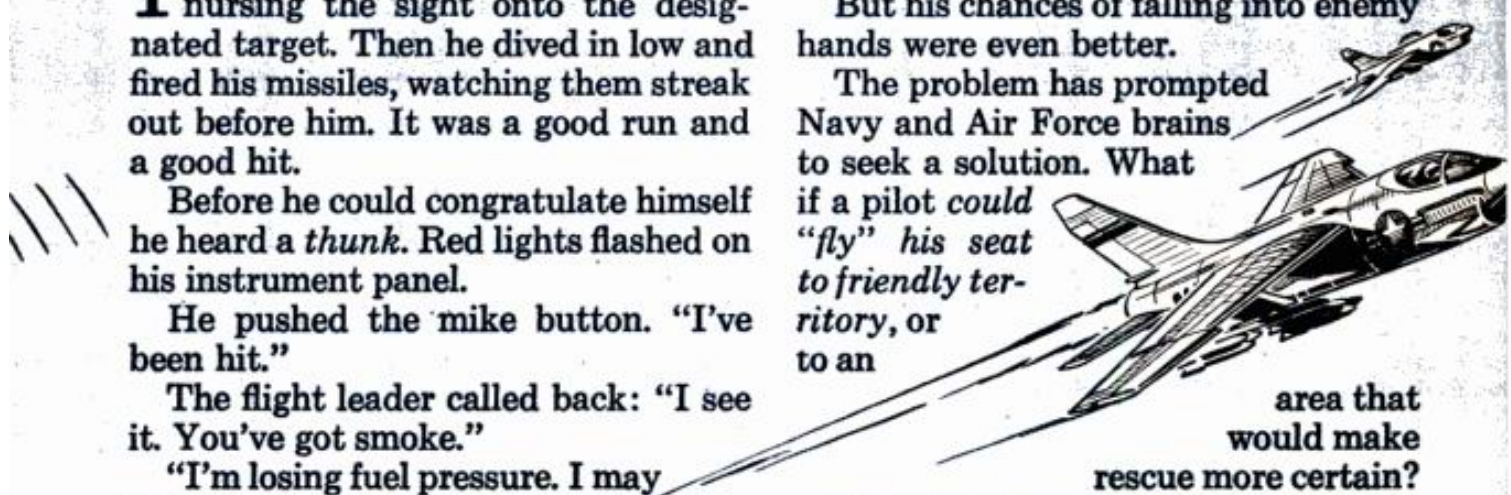
The problem has prompted Navy and Air Force brains to seek a solution. What if a pilot could "fly" his seat to friendly territory, or to an

area that would make rescue more certain?

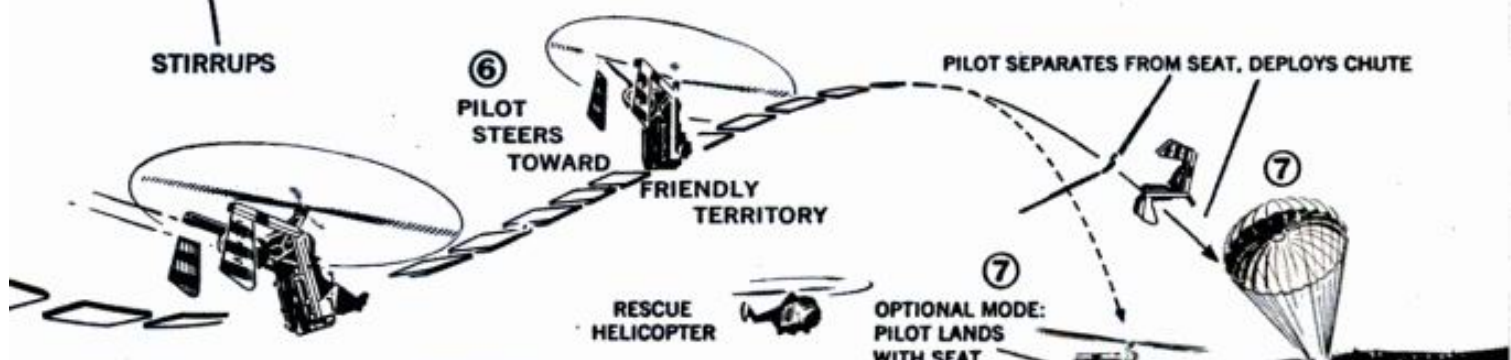
The Air Force and the Navy are working together to develop a "flying ejection seat" that can be stowed on a standard cockpit seat, deployed after the seat ejects, and, with a small jet engine, keep the pilot airborne until he can select his landing site.

Three versions of the AERCAB (Aircrew Escape/Rescue Capability) are now under study. One is based on the Rogallo wing, a triangular-shaped cloth supported by three keels. The Air Force's Wright-Patterson Flight Dynamics Laboratory is testing it with Bell Aerosystems Co., of Buffalo.

The second version is a two-bladed, free-swinging rotor that, with a jet en-



STIRRUPS



gine, converts the seat into a gyrocopter. The Navy Air Development Center, Johnsville, Pa., is studying this version. Contractor is Kaman Corp., Bloomfield, Conn.

The third version is based on the Princeton sailwing, which features cloth-covered wings and tail surfaces held taut by spring-loaded metal bars and cables. The Navy Air Development Center is studying this version with Stratos Western Div. of Fairchild Hiller Corp., Manhattan Beach, Calif.

Whichever system is picked must meet these specifications:

- Pilot has option of using the system—or his own parachute if he *knows* he's over friendly territory.

- ② ● After punch-out, the system will be automatic, but pilot will have option of overriding it at any time. The automatic feature insures that a wounded (or semiconscious) pilot can

use it, with the seat flying a predetermined heading and altitude.

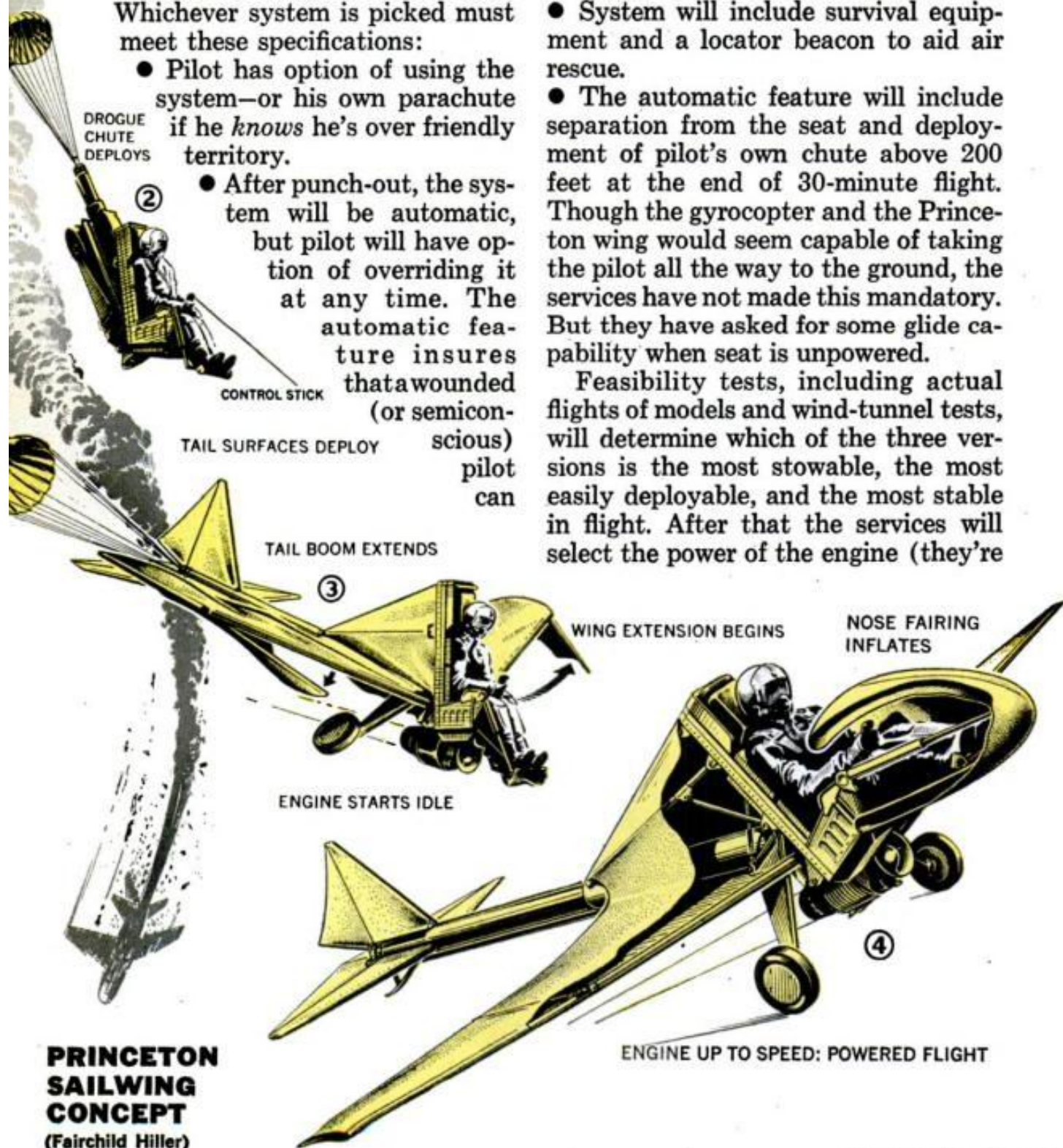
- A barometric sensor will keep the system from deploying until it descends to 10,000 feet. If it deployed above that altitude, the pilot could suffer from exposure and use up his oxygen too quickly. If the pilot punches out below 10,000 feet, deployment sequence begins immediately.

- Seat must be capable of a speed of 100 knots, a rate of climb of 1000 feet per minute and a range of about 50 miles.

- System will include survival equipment and a locator beacon to aid air rescue.

- The automatic feature will include separation from the seat and deployment of pilot's own chute above 200 feet at the end of 30-minute flight. Though the gyrocopter and the Princeton wing would seem capable of taking the pilot all the way to the ground, the services have not made this mandatory. But they have asked for some glide capability when seat is unpowered.

Feasibility tests, including actual flights of models and wind-tunnel tests, will determine which of the three versions is the most stowable, the most easily deployable, and the most stable in flight. After that the services will select the power of the engine (they're



**PRINCETON
SAILWING
CONCEPT**
(Fairchild Hiller)

ROGALLO WING CONCEPT

(Bell Aerosystems)

PILOT BLOWS OUT CANOPY

PILOT PUNCHES OUT

PLANE DISABLED OVER ENEMY TERRITORY

DROGUE CHUTE DEPLOYS, PULLING OUT WING

WING DEPLOYS, EXTENDS TO FLIGHT POSITION

PILOT AND SEAT ASSUME FACE-DOWN FLIGHT POSITION

ENGINE STARTS

POWERED FLIGHT

FLIGHT CONTROLS

thinking of up to 250 pounds of thrust) and decide whether to design a new seat or go with the one now in use.

The current ejection seat (Navy and Air Force seats are basically the same) has almost perfect dependability. Pilots have punched out successfully from zero-zero attitude (no altitude, no ground speed) up to and through the sound barrier. Should ejection be necessary at high speeds with the new systems, built-in devices will slow down the seat before deployment begins.

Here's how a typical punch-out would work with each system, assuming an altitude below 10,000 feet and subsonic speeds. The initial sequence would be identical for all.

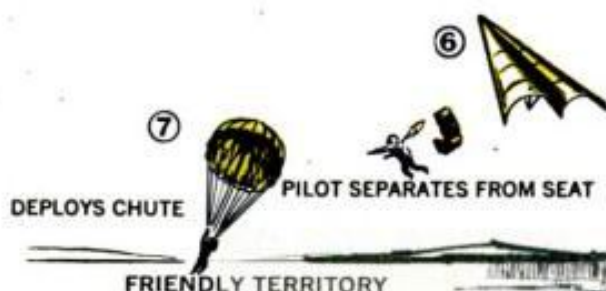
As in the present Air Force seat — to use it as an example — the pilot pulls up on two red handles alongside the seat below his knees and follows through until his helmet hits the head-

rest. Cables yank his feet back against seat to make certain his legs clear the instrument panel on the way out.

The canopy blows off, rockets ignite and seat rides on rails out of cockpit. The angle of ejection is slightly forward to brace pilot and seat against the rush of wind. In the current system, at this point pilot and seat separate, and pilot's chute opens.

With the new systems, a deceleration

(Please turn to page 197)

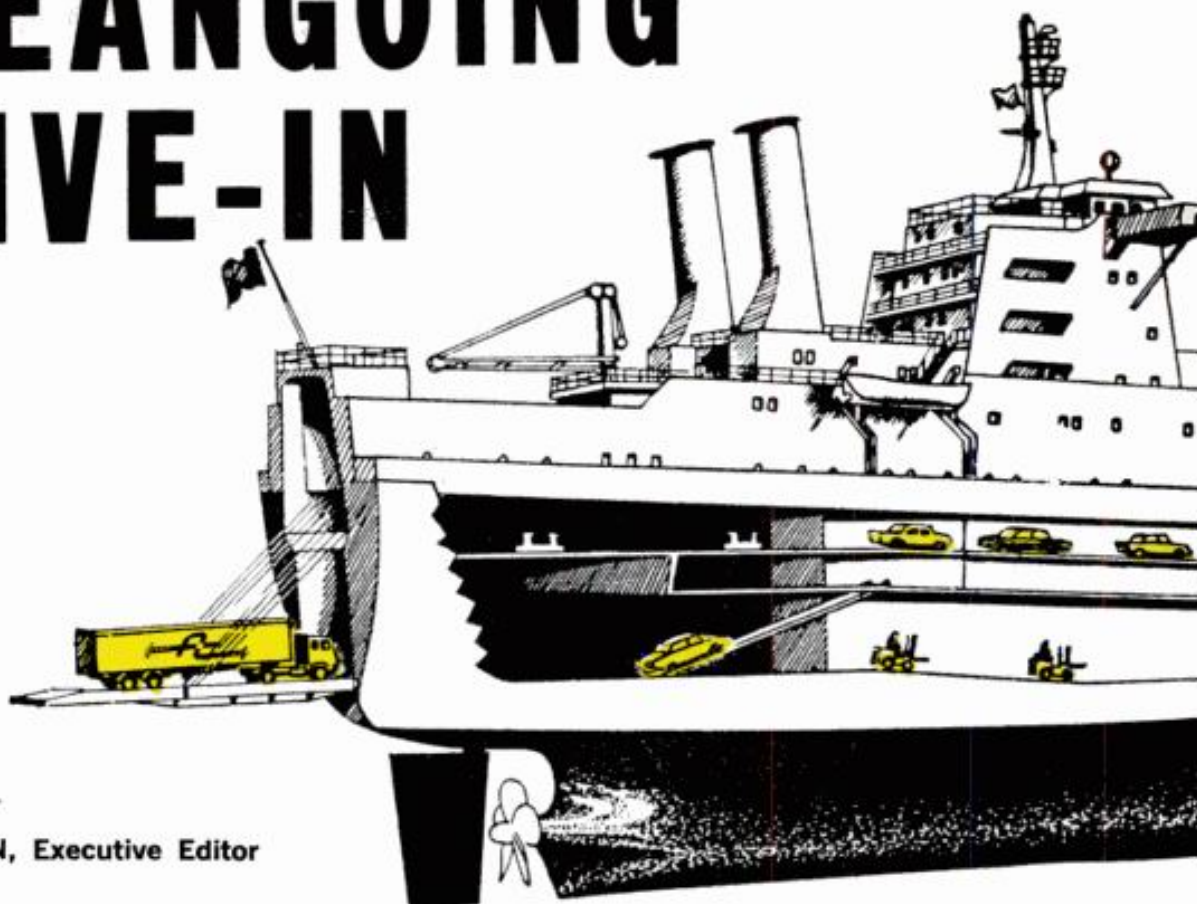


RESCUE HELICOPTER

PILOT STEERS TOWARD FRIENDLY TERRITORY

ENEMY TERRITORY

OCEANGOING DRIVE-IN



By JIM LISTON, Executive Editor

CONTAINER SHIPS—vessels whose cargo is carried in standardized shipping containers to speed loading and unloading—are fast making general cargo ships obsolete. The result has been that shippers of odd-shaped and oversized cargo—autos, tractors, buses, bulldozers, farm machinery, steam shovels—have found themselves boxed out. Their products don't fit into standard containers.

The answer is a new type of cargo vessel, known as a roll on/roll off (RO/RO) container ship, that handles almost anything that can be pushed, pulled or driven aboard. The cargo is wheeled into the vessel over a stern ramp that is lowered to a floating platform attached to the dock. While containers are being lifted aboard by overhead cranes, RO/RO cargo rolls in over the ramp.

The new concept in cargo transportation was introduced by Atlantic Container Line, Ltd., a consortium of six major steamship lines: Cunard, The French Line, Holland-American, Swed-

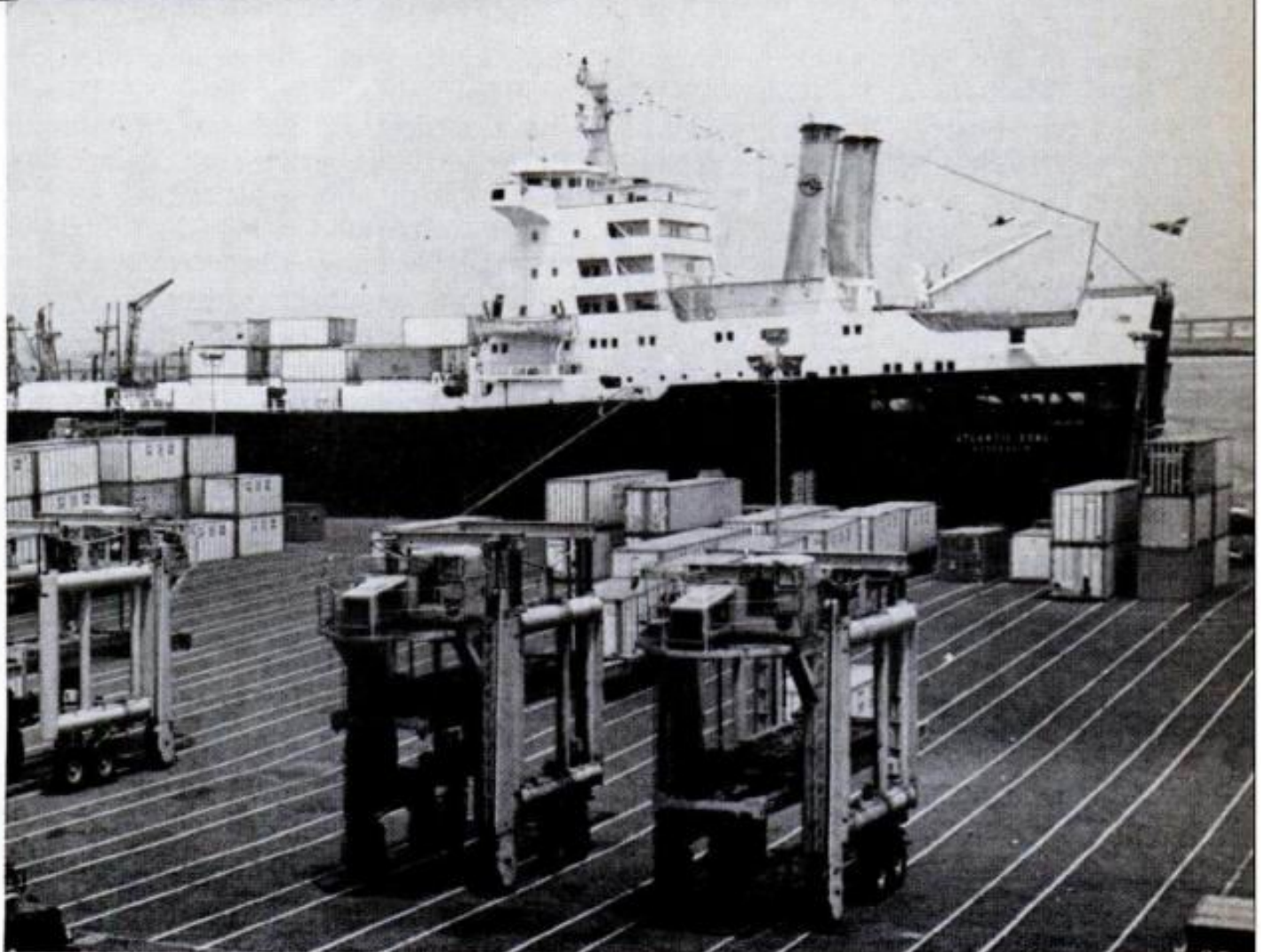
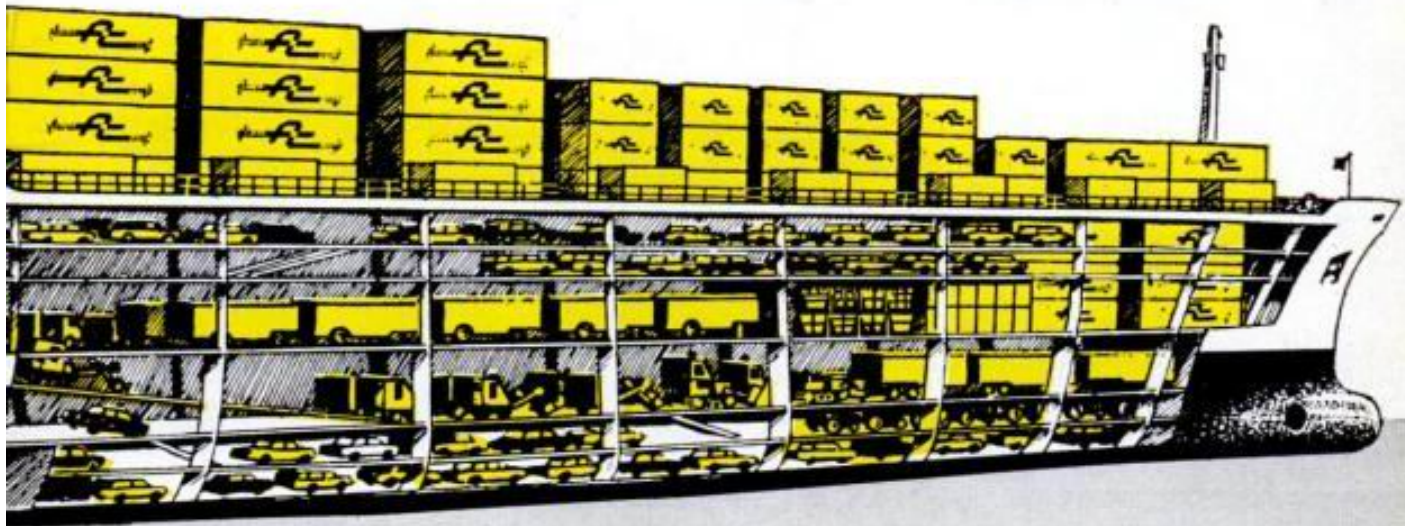
ish American, Swedish Transatlantic and Wallenius Line.

Four of the new ships, *Atlanta Star*, *Atlantic Saga*, *Atlantic Song* and *Atlantic Span* each carry 485 20-foot containers or 227 40-foot containers, or a mixture of both sizes. Containers are carried on the upper deck or in the forward part of the hold. In addition, each ship can carry 1150 automobiles plus a mixed cargo of rolling stock. The six internal decks provide a cargo space of nearly two million cubic feet. The ships are 646 feet long, 86 feet wide, carry a crew of 27 and are powered by 20,700-hp diesels producing an operating speed of 21 knots.

The ACL ships are equipped with an advanced electronic system that provides full directional control from the bridge. Exceptional maneuverability in port is made possible by a 1000-hp bowthruster that precisely steers the bow of the ship.

Six larger and faster "second generation" ACL ships will be in service early next year. The first of these, *At-*

Spanning the North Atlantic like a giant, floating conveyor belt, new fleets of fast cargo ships carry heavy trailer trucks, farm machines and road-building equipment—all rolled on and off as easily as cars on a ferryboat



STRANGE-LOOKING STRADDLE CARRIERS wheel cargo containers up to the ship's side, ready for load-

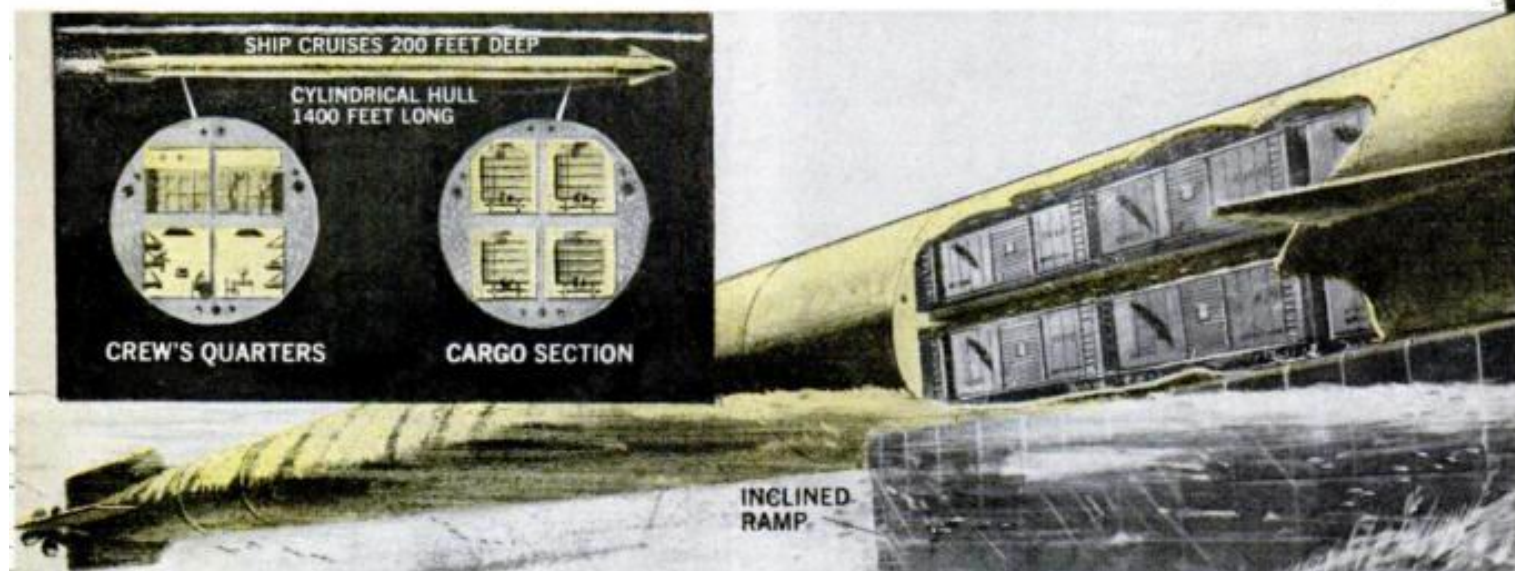
NOVEMBER 1969

ing. Standing 27 feet high, the long-legged, motor-driven vehicles can stack containers three high

Just patented

PM'S PICK OF THE NEW INVENTIONS

Prepared in cooperation with Roger S. Shashoua, Director, International Inventors Assn., Inc.

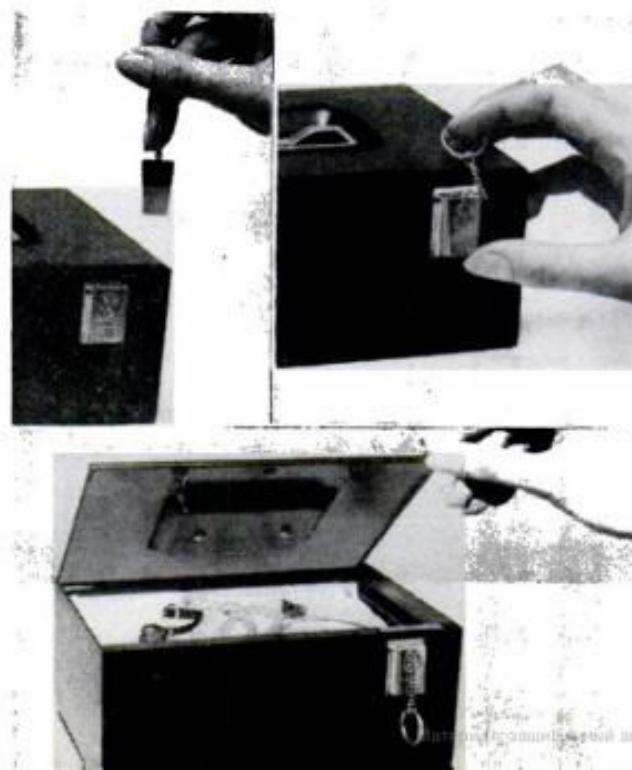
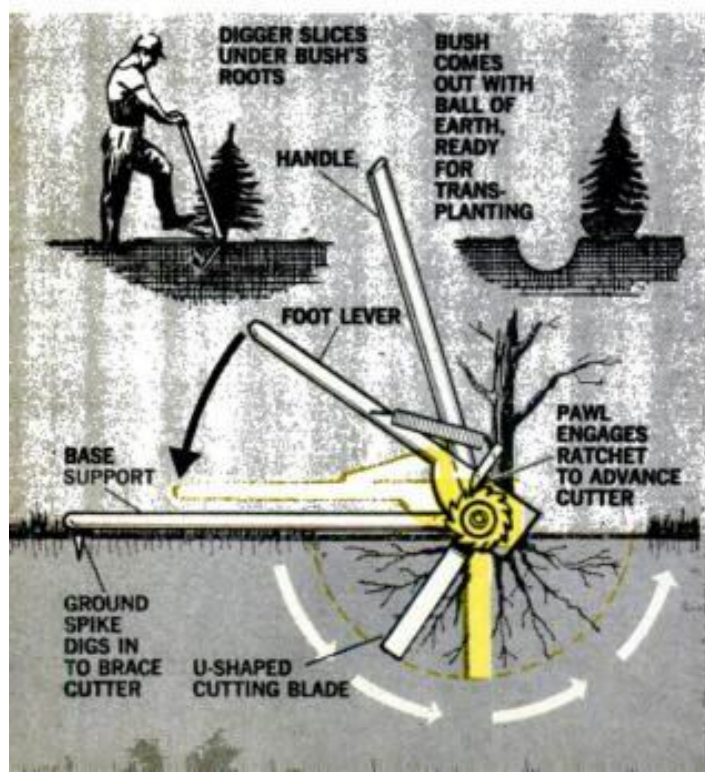


1. SLITHERING THROUGH THE WATER like a giant eel, this 1400-foot-long cargo submarine could carry loaded freight cars to world seaports at speeds up to 45 mph. The tubular atomic-powered ship holds 100 cars on four tracks and cruises 200 feet deep. At the end of its run, it slides up a shallow

ramp on shore. Its nose swings open and the inside tracks are linked to tracks on land for unloading the trains. The underwater freighter would be unaffected by surface storms and is so simple to run it would require a crew of only six or eight compared to the 40 to 50 needed on a conventional freighter

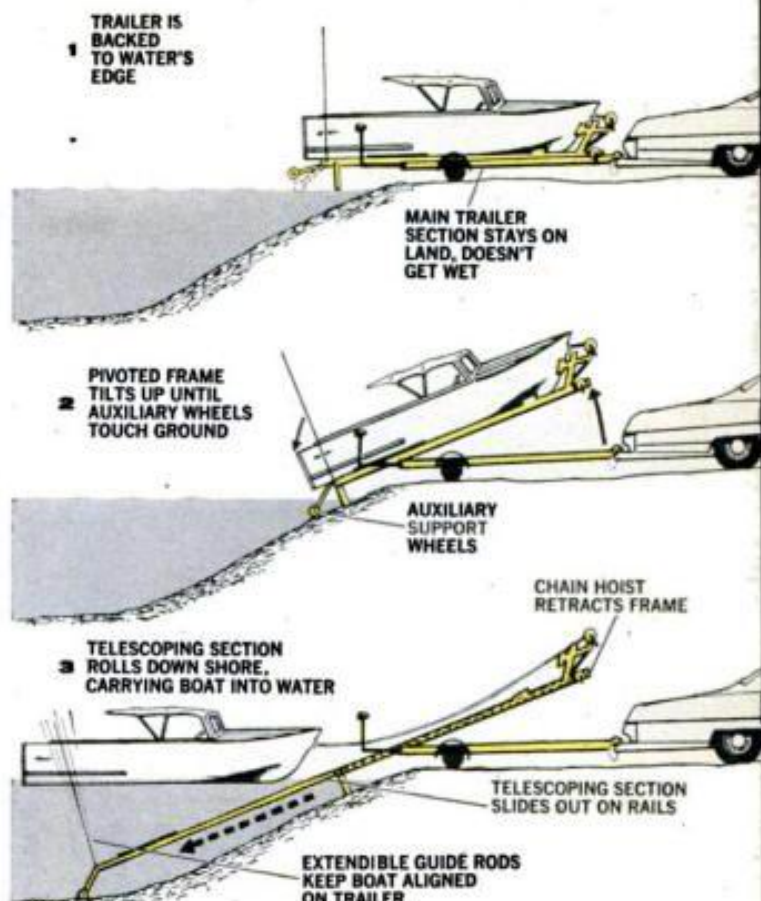
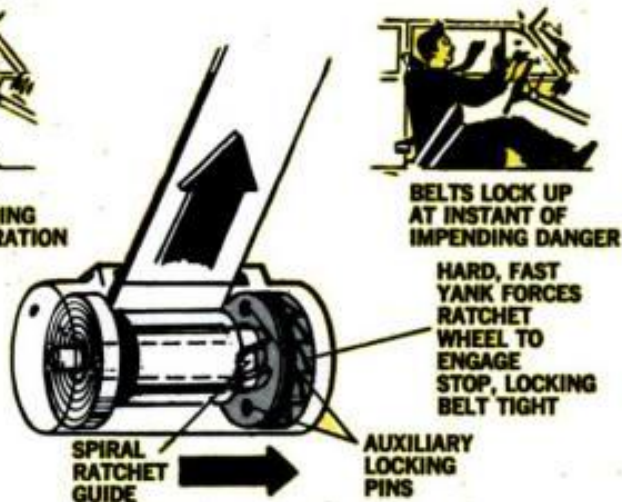
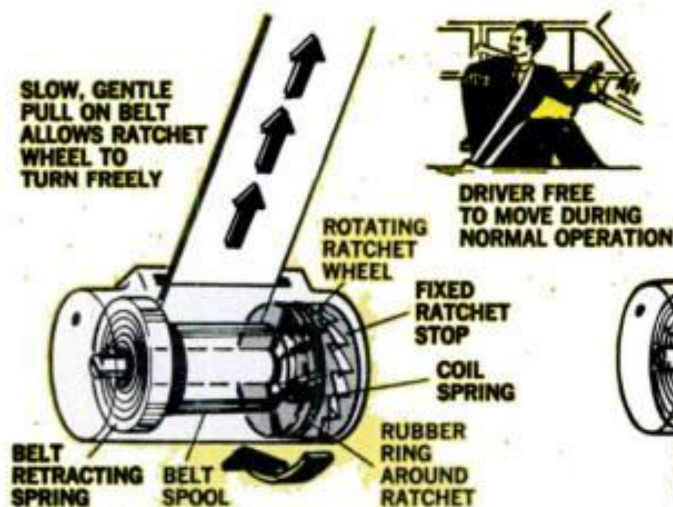
2. TRANSPLANTING SMALL TREES and bushes is a cinch with the mechanical digger below. You just pump a lever up and down with your foot and a sharp-edged cutting blade slices down and under the roots to free the tree from the ground. Each pump of the lever causes a spring-loaded pawl to engage a ratchet, advancing the cutter a few inches at a time. The blade's curved shape automatically leaves a ball of earth around the roots so that the tree can be replanted quickly and safely in another location

3. THE "KEY" IN THIS LOCK is a tiny magnet. Remove it and the box can't be opened. Slip it into the slot on front and the lid magically lifts up. Each key is magnetized in a different polar pattern. A magnet of matching pattern is built into the box. When the two are placed together, their combined fields trigger an electronic sensor inside the box, opening the lock. Only a magnet of the correct pattern will actuate the device. In larger versions, the lock could make burglarproof doors and safes





4. SELF-LOCKING SEAT BELT below leaves you free to move around comfortably in normal driving, but holds you tightly at the first sign of danger. A spring-loaded hub lets you pull the belt out so long as you do it slowly and gently. A sudden yank causes a ratcheted-toothed wheel to fly out sideways in a spiral guide, engaging a similarly toothed fixed ratchet and locking the belt. In a sudden stop or impact, two pins also fly out, catching in the fixed ratchet and stopping the belt. If there's a sideways impact, a rubber ring around the ratchet wheel snubs up against the housing. This keeps the ratchet from turning and forces it to ride out in the spiral guide, locking against the fixed ratchet



5. YOU CAN LAUNCH A BOAT from the telescoping trailer above without backing the trailer into the water. This keeps wheel bearings dry and lets you tackle slopes that would be too steep for a normal trailer. At the water's edge, the boat is tipped up on a pivoted inner frame. The cradle then slides out on two rails, riding down the bank on small wheels. As the boat is carried into the water, it floats free and the cradle is retracted by a hoist. Two extendible rods sticking up at the ends of the telescoping rails keep the boat lined up straight so that it can't drift sideways during the operation

Inventors of the items shown on these pages are as follows: 1. Dr. Robert L. Whitelaw, Virginia Polytechnic Institute, Blacksburg, Va.; 2. Charles N. Dickey, 9836 Auburndale, Livonia, Mich. 48150; 3. Edwin Drescher, Melsunger Metallwerk, P.O. Box 268, 3508 Melsungen, West

Germany; 4. A. B. Svenska Metallverken, Upplands Vasby, Sweden; 5. Andrew Scott, 7366 Bannock Trail, Yucca Valley, Calif. 92284. Roger S. Shashoua can be reached at the International Inventors Assn., Inc., 680 Fifth Ave., New York, N. Y. 10019.

OWNERS REPORT ON THE PLYMOUTH

POPULAR MECHANICS MAGAZINE

WRITTEN SO YOU CAN UNDERSTAND

MAY 1956

35 CENTS



Read what happens when
THE ATOM STRIKES A VALLEY

Outboards Jam the Water

For the Craftsman

Build Your Own Greenhouse
CAMPING IN A STATION WAGON

*French Revolution
in the Air—page 112*



The New French Revolution—in the Air

Text and Paintings by G. H. Davis

EARLY AVIATION HISTORY is filled with the names of French aeronautical designers and builders—Voisin, the Farman brothers, Bleriot, Breguet, Nieuport and many others. From the first investigations of powered flight up through World War I, French planes were among the world leaders.

But between the two world wars, the United States, Great Britain and Germany raced ahead in aircraft development, while in France the industry seemed overcome with lethargy. At the air shows there were always ultramodern models displayed by French engineers—but these seldom got out of the model stage. France had an advanced air fleet on the drawing boards and, unfortunately, an obsolete one in the air.

This was the condition at the outbreak of World War II, when German Stuka dive bombers roared

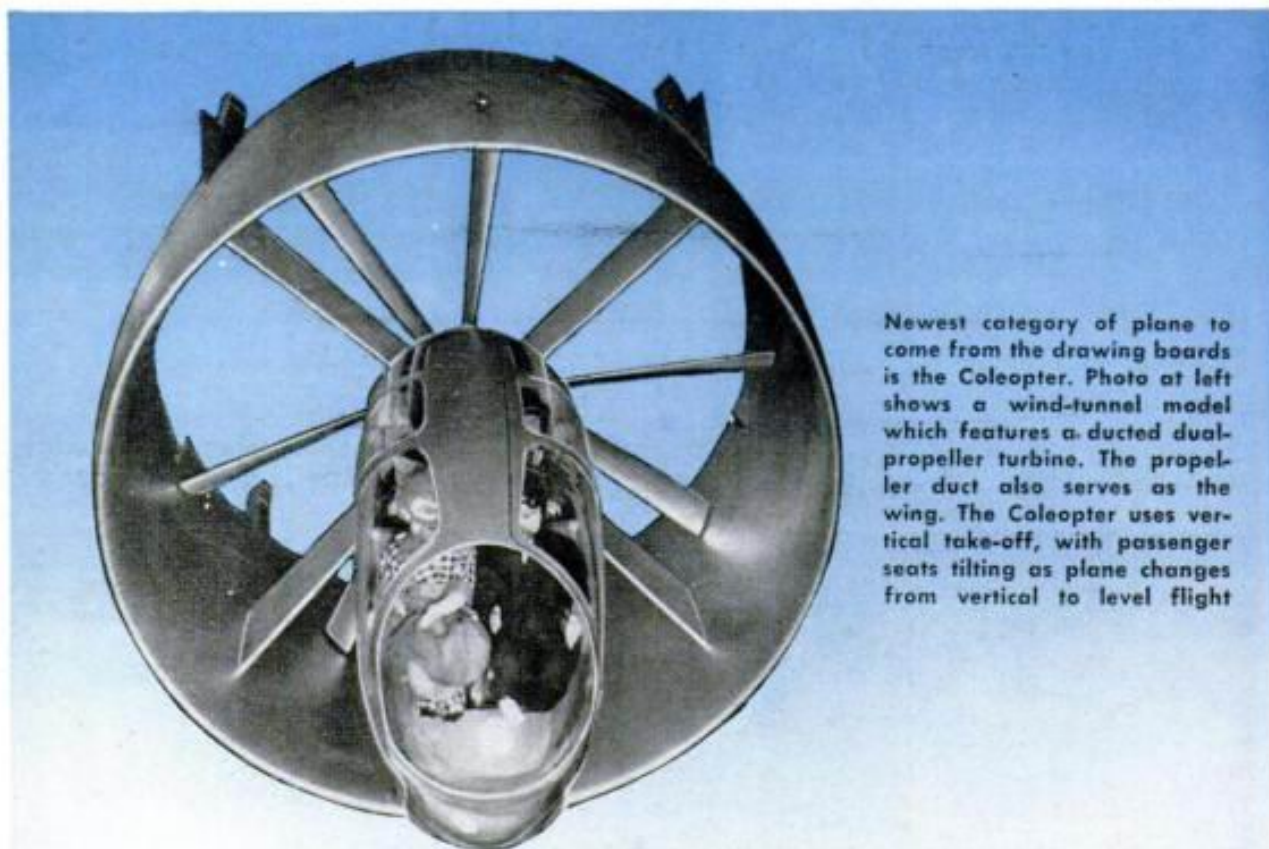
through the sky. The French had nothing that could cope with them, even though the Stuka later proved to be vulnerable when opposed by the modern fighters of the United States and Great Britain.

Following World War II, French aeronautical designers continued to produce plans for aircraft of an advanced and even revolutionary nature. But few were built.

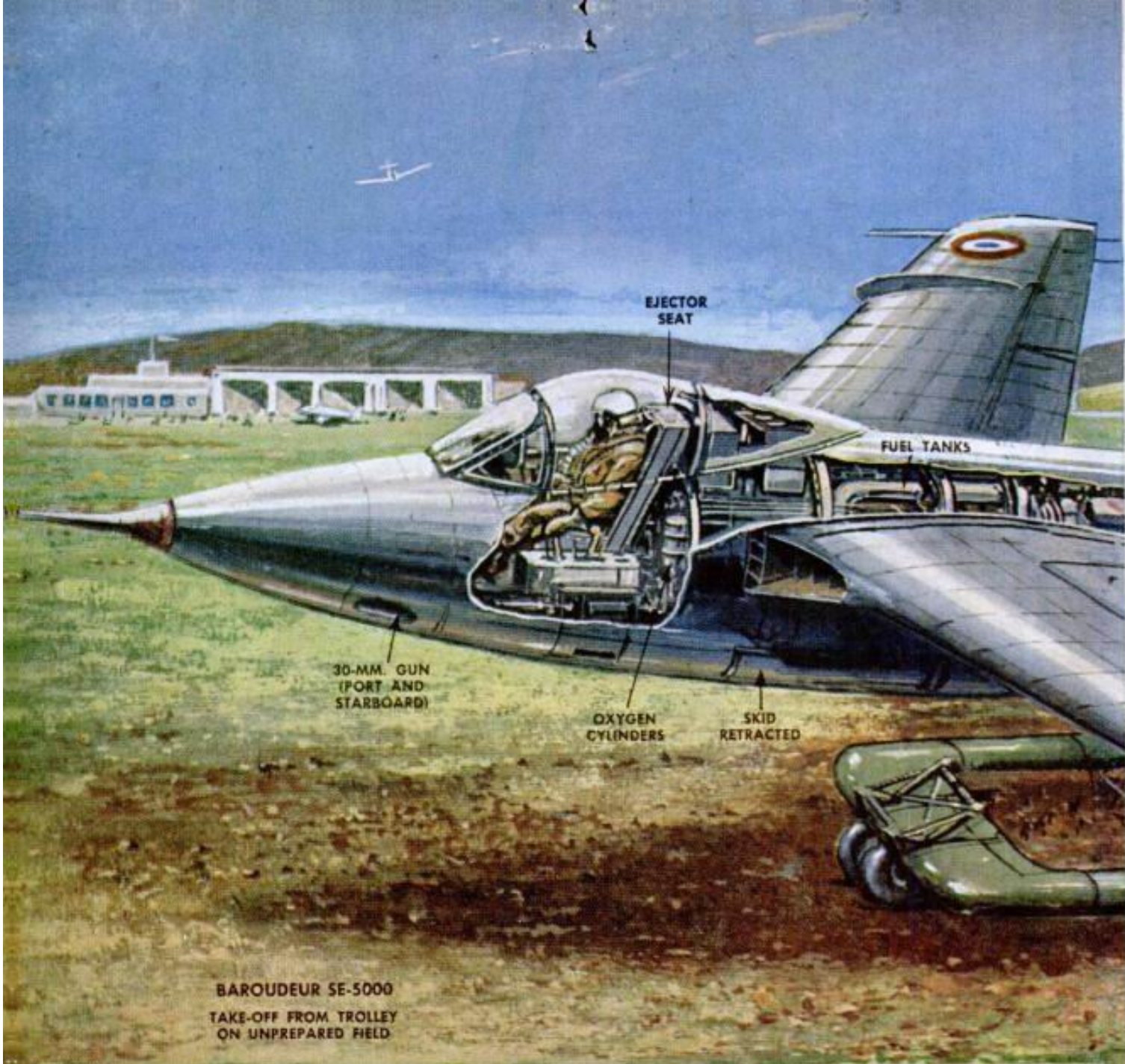
In the last few years, however, there have been unmistakable signs of a change in France—perhaps the ground swell of an aeronautical revolution. French inventiveness and ingenuity have continued at a high level, and more and more new French types are getting beyond the blueprint and model stages, as prototypes are built and experimentally flown.

On these pages we show a few of the excellent designs that have been flown in France recently. ★★

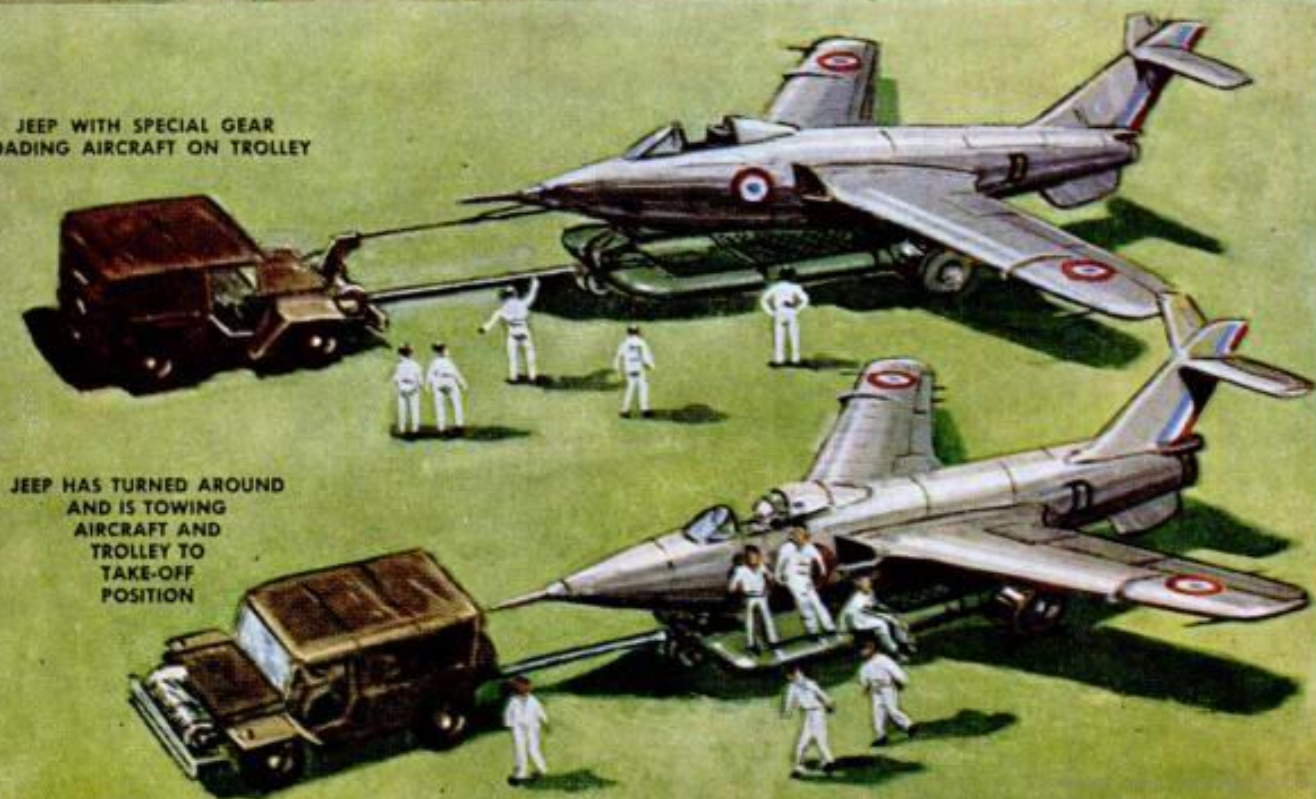
Mr. Davis, internationally known British artist, journeyed to France to make these on-the-spot paintings for *Popular Mechanics Magazine*

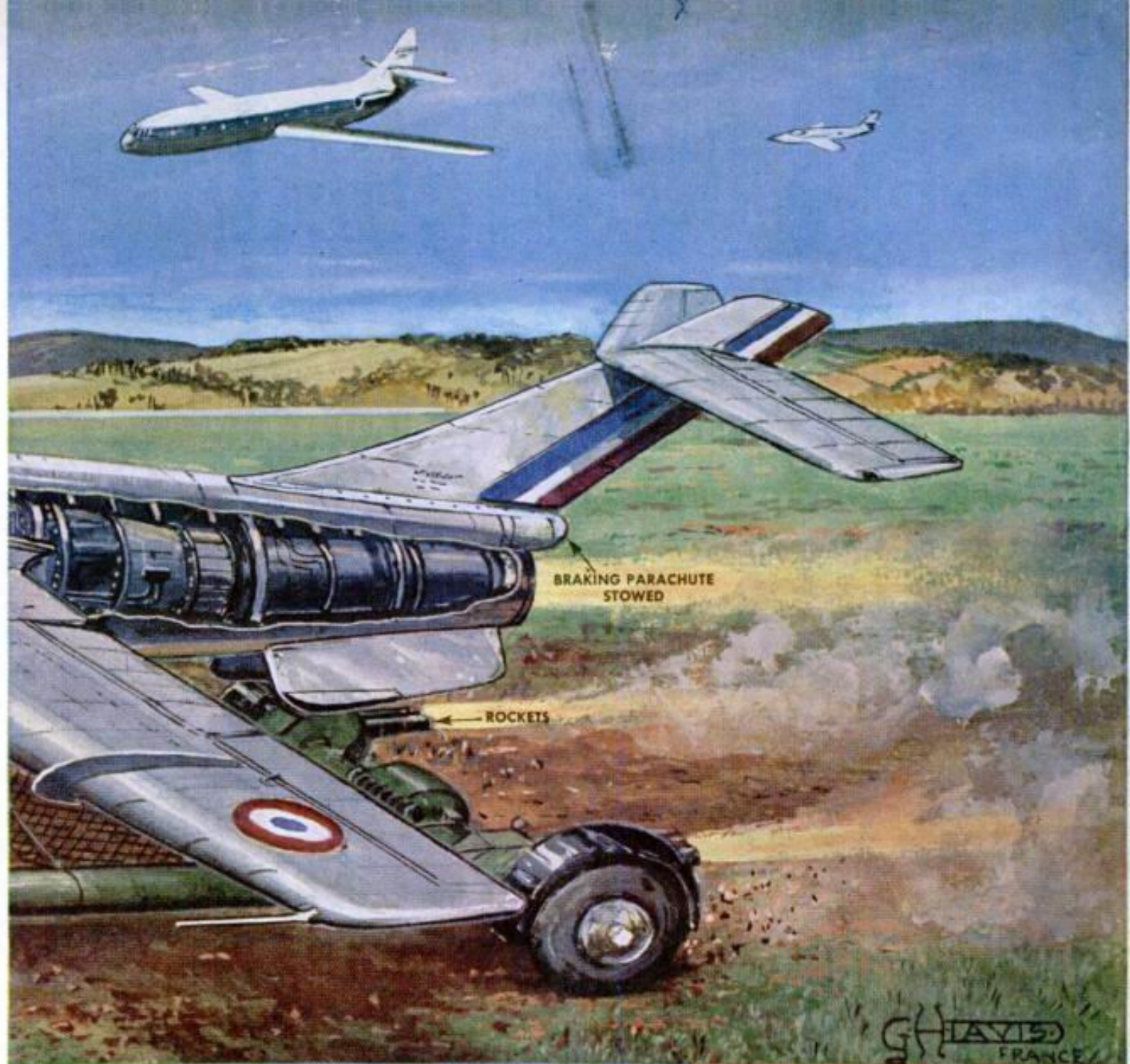


Newest category of plane to come from the drawing boards is the Coleopter. Photo at left shows a wind-tunnel model which features a ducted dual-propeller turbine. The propeller duct also serves as the wing. The Coleopter uses vertical take-off, with passenger seats tilting as plane changes from vertical to level flight



JEEP WITH SPECIAL GEAR
LOADING AIRCRAFT ON TROLLEY



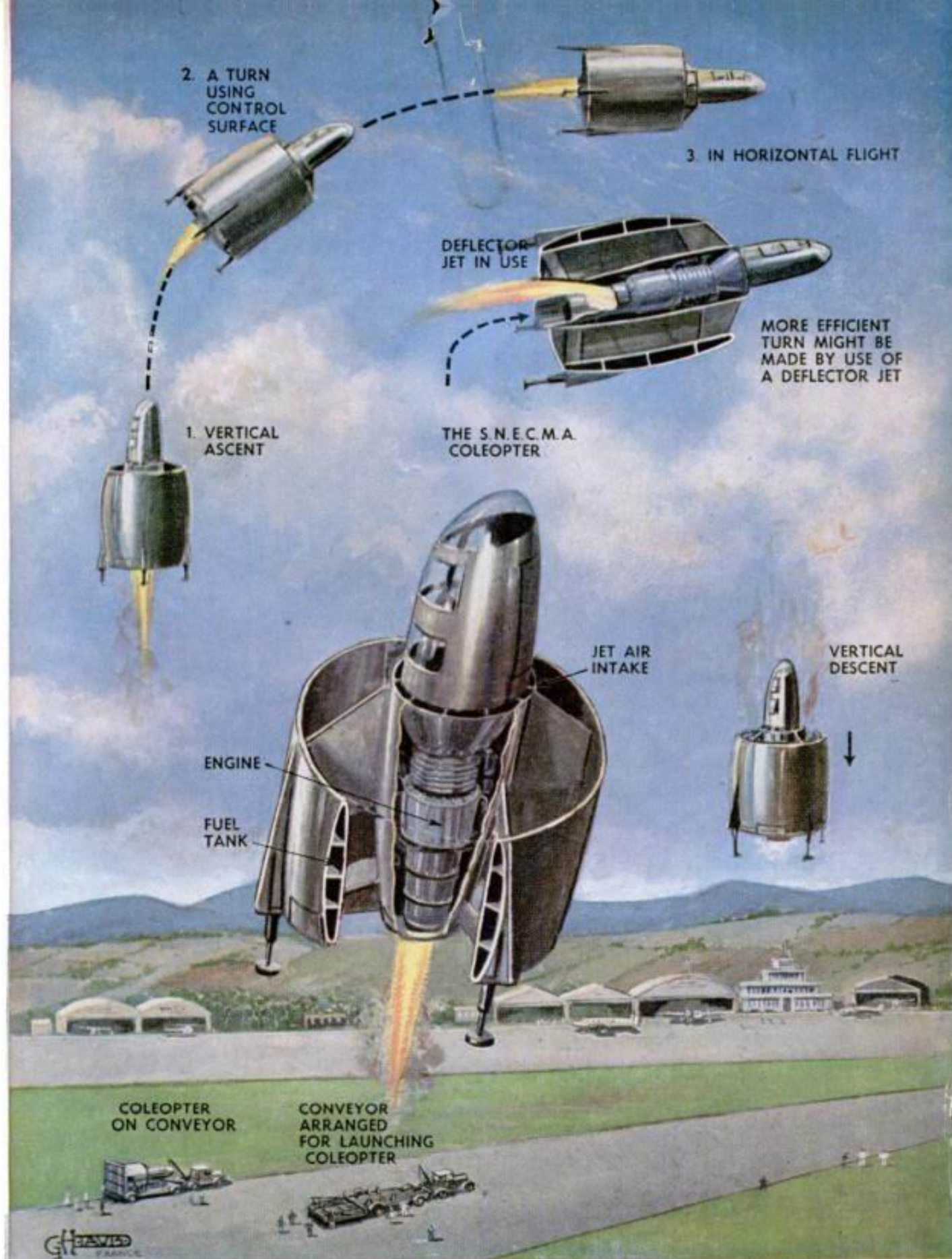


G. HAYES
FRANCE

AIRCRAFT LANDING ON ITS SKIDS
WITH BRAKING PARACHUTE IN USE

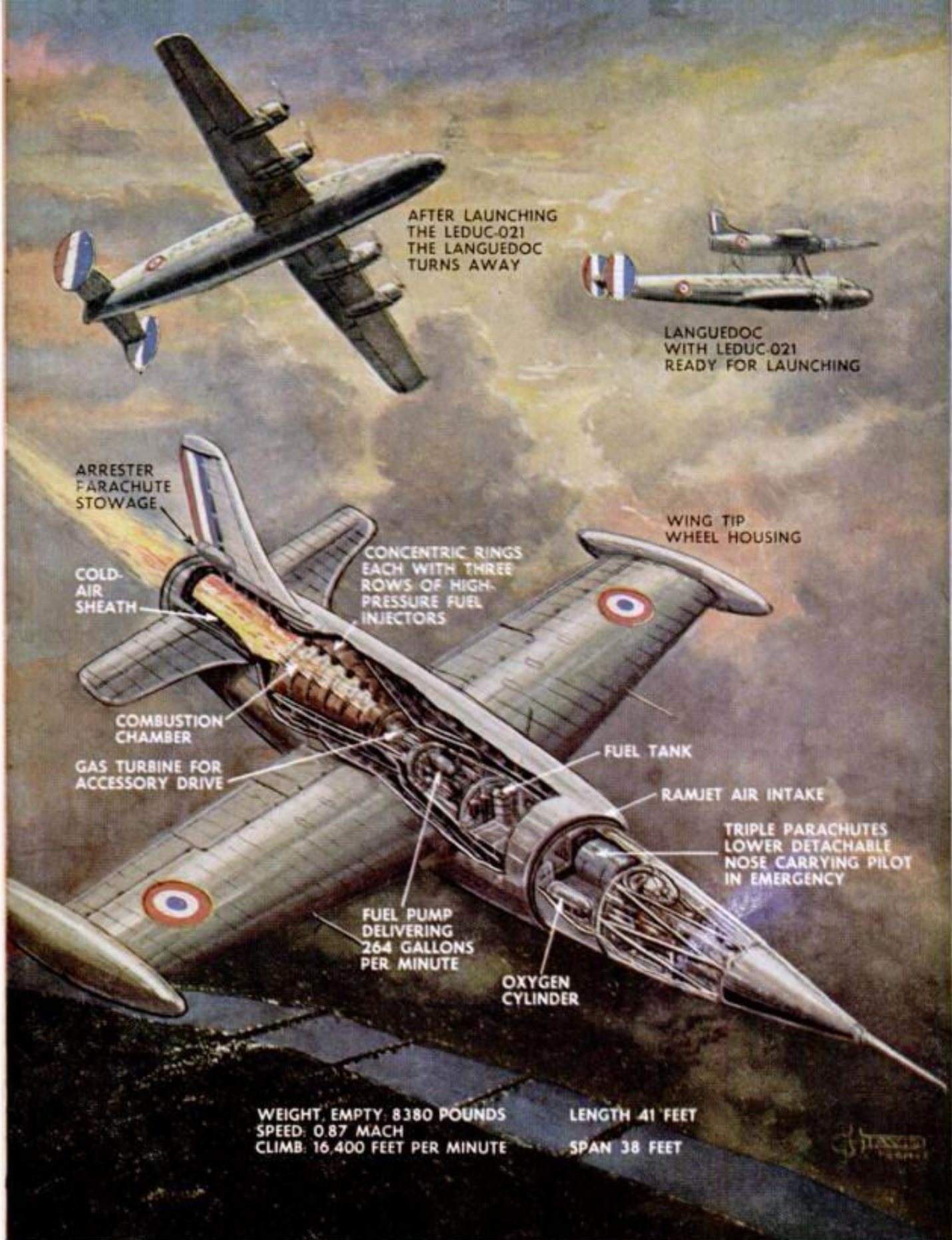


France has done a considerable amount of experimental work with aircraft suitable for NATO requirements, one of which is that the plane should be able to take off and land on unprepared grass fields. One of the most interesting types evolved is the Baroudeur SE-5000, a light fighter that is launched from a trolley and lands on skids. The trolley is provided with four rockets to give it sufficient speed to launch the plane. At take-off speed, the pilot cuts the trolley loose and climbs. The trolley is braked automatically. Tests have shown that the Baroudeur will fly with the trolley still attached. The take-off run is less than 770 yards. The transport above the Baroudeur in the picture is the new Caravelle, designed for 70 passengers. Powered by two Rolls-Royce Avon turbojet engines, it has a range of 1500 miles



Military version of the Coleopter, shown above, is powered by an Atar 101-E jet engine. Wind-tunnel studies indicate that it would climb to 49,200 feet in two minutes, and have a speed exceeding Mach 2 in level flight. Designed and patented by Helmut von Zborowski, builder of the plant that produced the first rocket aircraft, the Messerschmitt 163, the Coleopter is being tested and refined by S.N.

E.C.M.A., French manufacturer of aircraft engines. The annular wing, which serves simultaneously as a lifting surface and a power-plant housing, is light in weight and easy to produce. Since the Coleopter is launched from a special truck-trailer, it requires no airport as a base of operations. One objection to the design: In the event that the engine failed, the crew would have no choice but to bail out



Leduc-021 is carried aloft on top of a Languedoc airliner, and when its ramjet engine starts building up power it is released. It has a ceiling of 65,000 feet and an endurance of 15 to 25 minutes after release. The central body is used to form a diffuser, with a duct to give maximum ram increase. The combustion chamber is formed by a number of concentric rings, each of which carries a triple ring of

high-power injectors or burner-nozzles. A turbine in the assembly is used for an accessory drive and also provides the flame for ignition. The shroud narrows at the rear to give the burning gases added velocity as they escape. In the event of an emergency, the entire nose section is detached from the plane with the pilot still in place and three parachutes lower it to the ground. Designer is Dr. Rene Leduc

SPLIT RUDDER
ACTS AS
AIR BRAKE

NOTE SIZE OF
PILOT FOR COMPARISON

NOTE
CURVED
LEADING EDGE



EXPERIMENTAL
PAYEN P.A. 49
CLAIMED TO BE
THE SMALLEST
FIGHTER
IN THE WORLD



THE VERY
SUCCESSFUL
"TAON"



AT LEAST TWO OF
THE LARGE AIRCRAFT
FIRMS HAVE UNDER
DEVELOPMENT VERY
FAST DELTA-WING
LIGHT FIGHTERS

THE SECRET
"MYSTERE XXII-B"



WITH TWIN JETS

DASSAULT SECRET
EXPERIMENTAL DELTA-
JET WITH A SPAN OF
UNDER 14 FEET



THE "GERFAUT" 1402-B
CLAIMED TO BE THE FIRST
AIRCRAFT TO FLY SUPER-
SONICALLY IN LEVEL FLIGHT
WITH UNAUGMENTED POWER

TWO ROWS
OF VORTEX
GENERATORS

AFTERBURNER
ALSO FITTED IN
LATEST TYPES
STRAKE



DELTA WING
CONTAINING FUEL TANKS

ARRESTER
PARACHUTE
STOWED

30-MM. GUN
AMMUNITION
PACK

GUN PORT

AIR INTAKE
PASSING UNDER
COCKPIT FLOOR



MYSTERE
IV-B

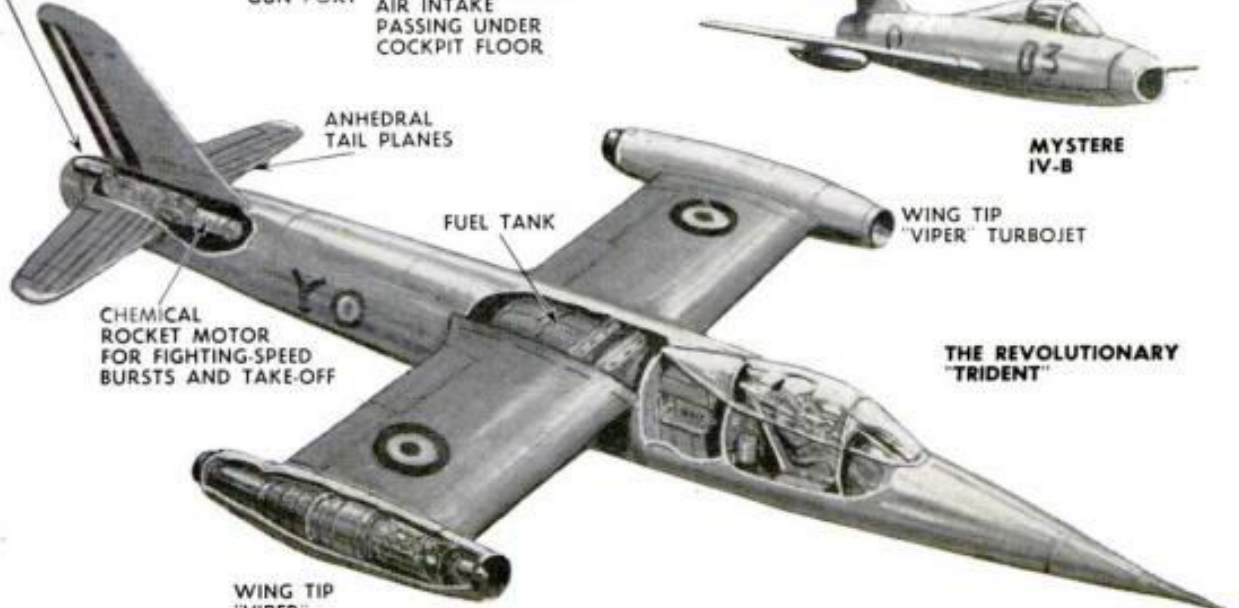
ANHEDRAL
TAIL PLANES

FUEL TANK

WING TIP
"VIPER" TURBOJET

CHEMICAL
ROCKET MOTOR
FOR FIGHTING-SPEED
BURSTS AND TAKE-OFF

THE REVOLUTIONARY
"TRIDENT"



WING TIP
"VIPER"
TURBOJET
1648-POUND THRUST



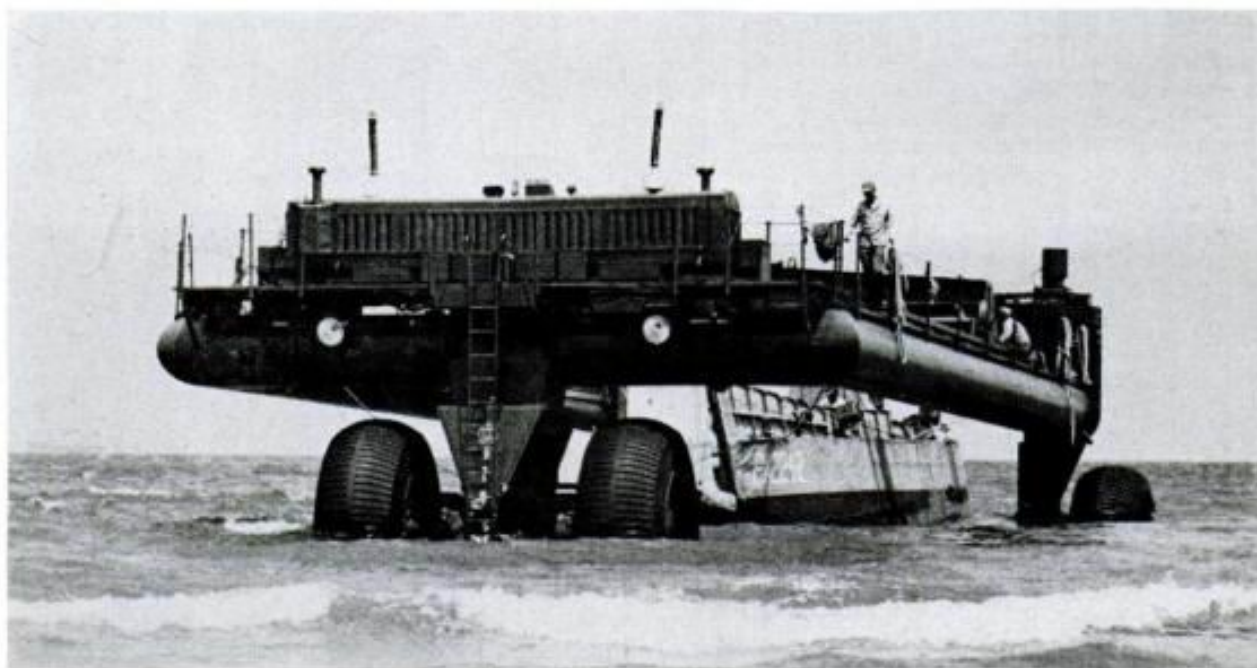
Heavy landing craft is dropped on the beach by the LeTourneau retriever at completion of salvage operation

Giant Retriever for Landing Craft

LOOMING like a huge sea crab in the surf, a retriever to salvage disabled landing craft is now undergoing tests at Fort Eustis, Va. The retriever, built by R. G. LeTourneau, Inc., of Longview, Tex., waddles into the surf and straddles any sunken landing craft, up to and including the 67-ton LCM-8. Then it either floats the boat or carries it to the beach. The secret behind the retriever's mobility is an electric motor and gear-reduction unit built into the center of

each wheel, where it operates in a water-proof housing cooled by air pumped in under pressure. Each wheel is equipped with the world's largest tire, 10 feet high and 4 feet wide, for traction in soft terrain. Eight floodlights are spotted on the vehicle for night operations. The retriever was developed after a study showed that only 10 percent of landing-craft losses were from enemy action. The rest resulted from mishaps during beaching.

Self-propelled retriever is operated by one man. Crew assists by attaching hoist cables to disabled craft



HELICOPTER TUG

West Coast designer foresees rotary-wing craft lowering and lifting tomorrow's transports and fighters in and out of small landing sites

JET TRANSPORTS of the future may be lifted from downtown locations by high-powered helicopter tugs that would detach themselves after the transports attain flying speed. That's the expectation of Dr. J. A. J. Bennett of Hiller Helicopters, who

has applied for patents covering several features of the idea.

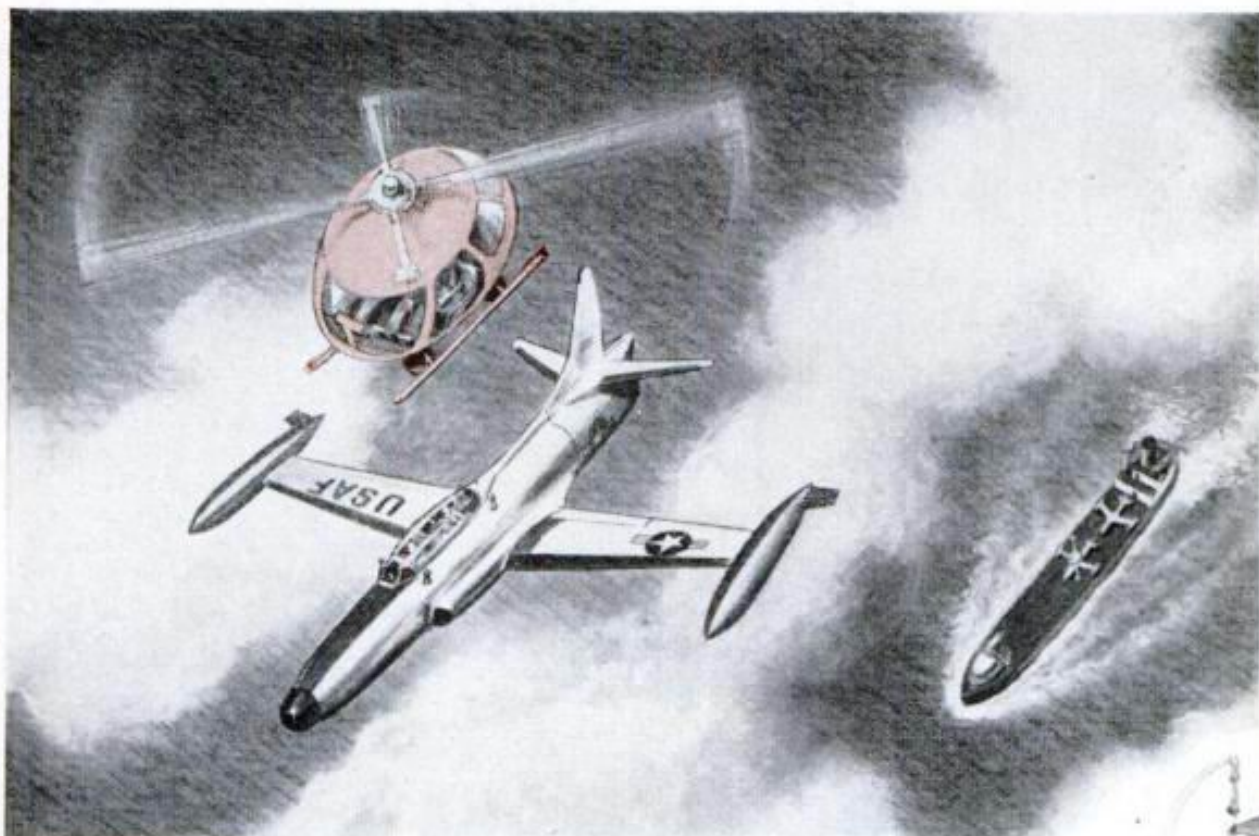
The same helicopter tugs could fasten themselves to incoming transports and lower them safely and almost vertically.

This new method of assisting fast aircraft in and out of small landing sites would eliminate the need for long runways and the present necessity of locating airports at considerable distances from city centers.

Other benefits are that transports no longer would require the heavy landing gear they now carry, and they could operate at higher wing loadings.



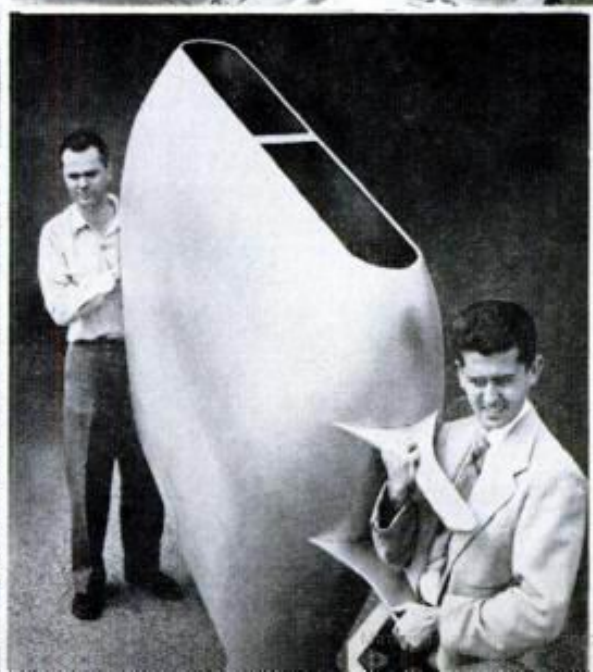
TO LAUNCH PLANES

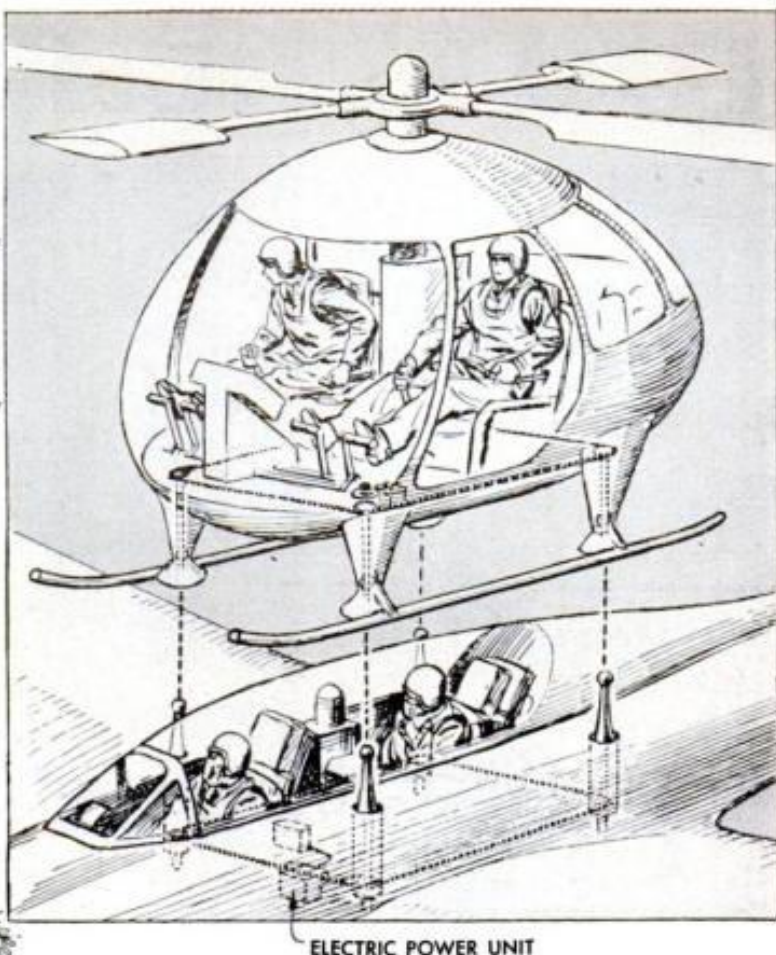
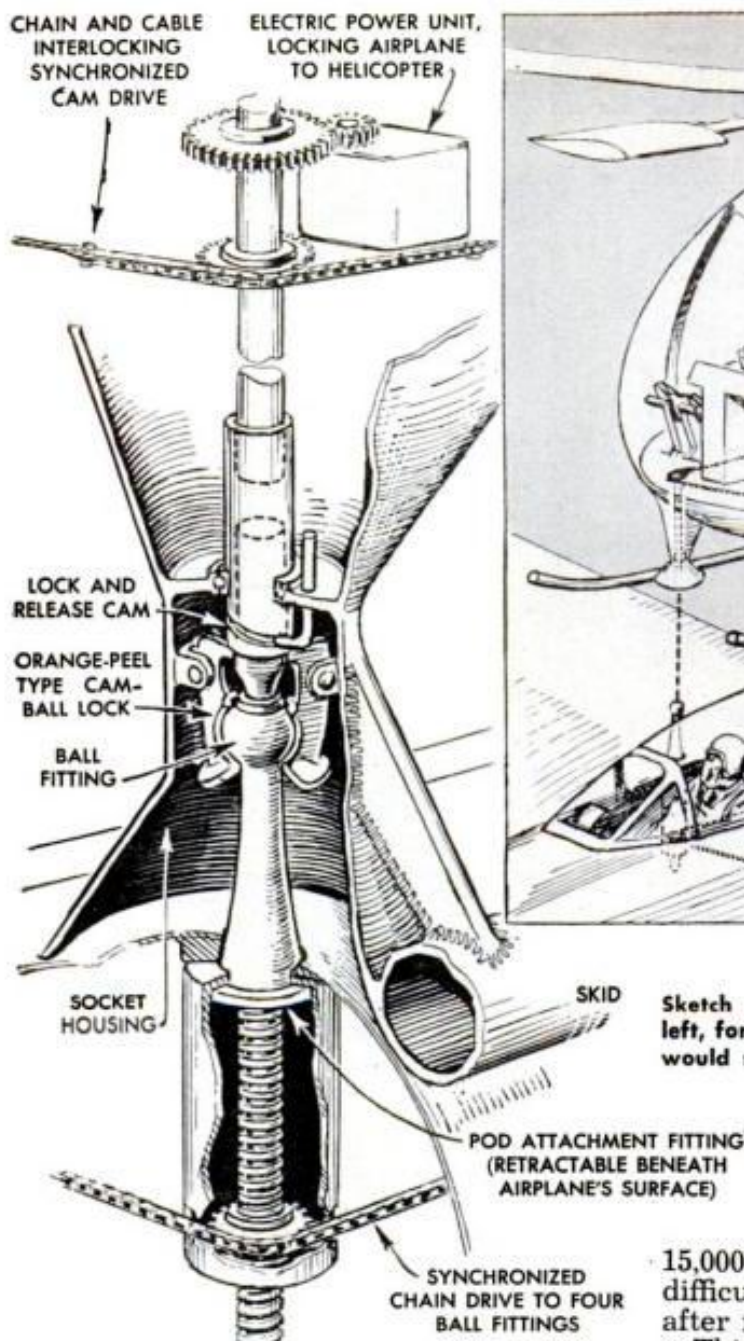


Jet fighters could be carried from cramped decks to sufficient altitude for release

Doctor Bennett points out that the problems associated with release and re-attachment in flight are somewhat comparable to those already solved in the refueling of aircraft by tanker planes. Methods of attachment by a helicopter tug riding piggy back on top of a transport are covered in his patent

Mockup of experimental ramjet engine, below, designed to produce more than 4000 horsepower for a future Hiller helicopter





Sketch of Doctor Bennett's quick-release mechanism, left, for locking airplane to helicopter. Carrying craft would straddle the cockpit canopy of fighter below

applications, together with quick-release methods. There appear to be no particular problems concerned with transitional speeds, and helicopters now being designed would be capable of attaining speeds fast enough to more than match the approach speeds of transports.

"The tug pilot would perform a function similar to that of a pilot at a port for ocean ships," Doctor Bennett explains. "He knows all the local hazards and is skilled in port navigation. This local knowledge would be especially valuable during a final let-down through cloud conditions. The tug and transport pilots would communicate by telephone meanwhile, similar to the intercommunication between the bridge and engineroom of a ship."

Helicopter tugs also would be valuable for launching fighter or search aircraft

from the deck of a ship. Doctor Bennett estimates that a helicopter tug having a rotor diameter of 75 feet and powered with ramjet engines at the rotor tips could lift a 15,000-pound fighter into the air without difficulty, then lower it again to shipboard after re-attachment.

This helicopter "elevator service" would permit full utilization of all available deck space for parked aircraft.

Large helicopter tugs will require ramjet engines of tremendous horsepower. One experimental design prepared by the Hiller propulsion section develops an estimated 4200 horsepower, providing a total of 8400 horsepower at the rotor tips.

Probably the helicopter tugs will dispense with the usual tail or antitorque rotor because of another Bennett development. Ramjet-powered helicopters require a small auxiliary engine to sweep the rotor blades around and thus start the engines. Doctor Bennett proposes that the auxiliary engine continue to apply power to the rotor shaft during the entire flight. This would balance the usual friction from hub bearings and accessories and allow the pilot to rotate the fuselage in either direction. ★ ★ ★

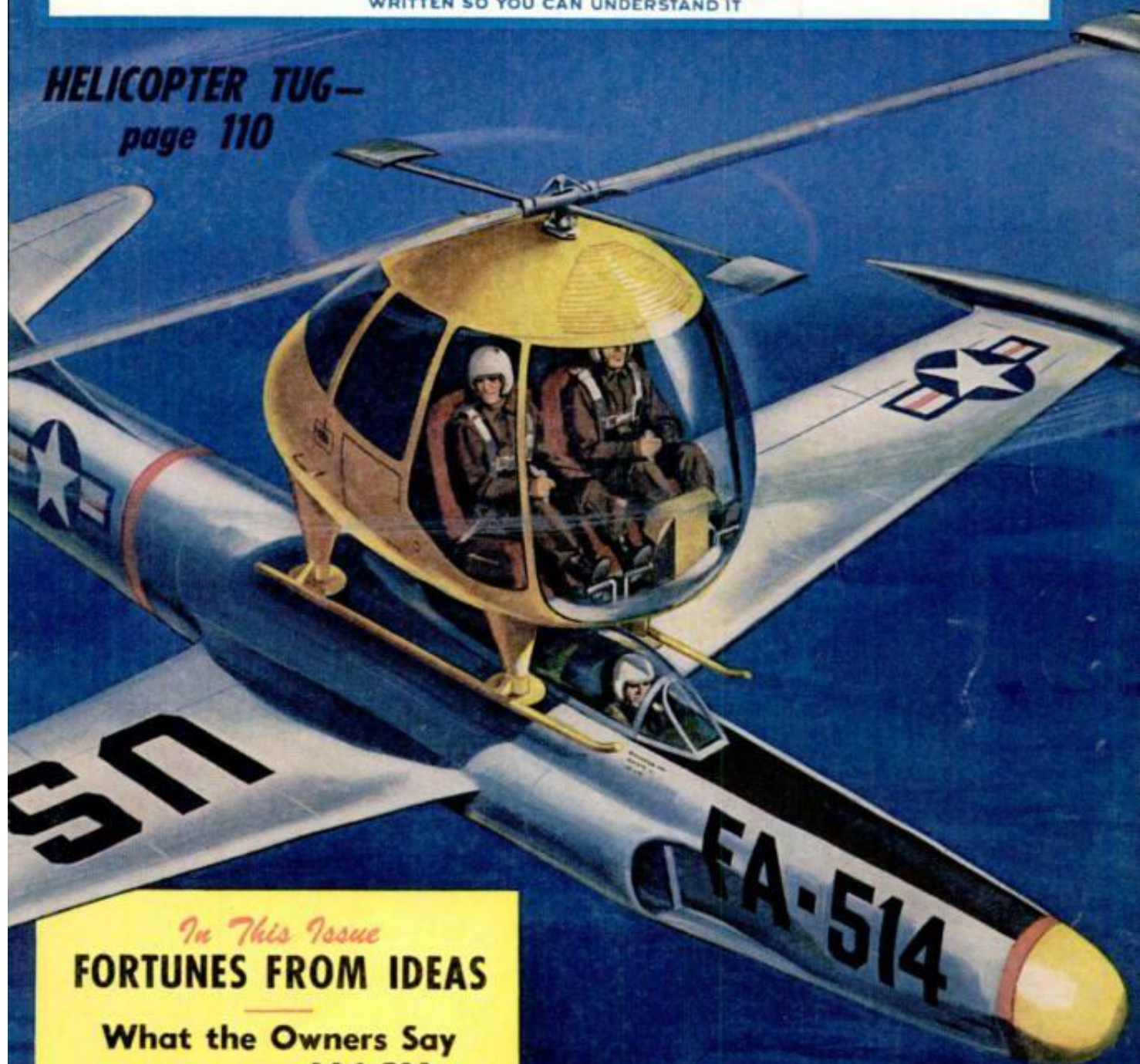
NOVEMBER 1953

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HELICOPTER TUG—
page 110



In This Issue
FORTUNES FROM IDEAS

What the Owners Say
About the **NASH**

For the Craftsman
Christmas Toys You Can Make

MARCH 1953

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ANC

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Skyhook for a Rocket
page 103

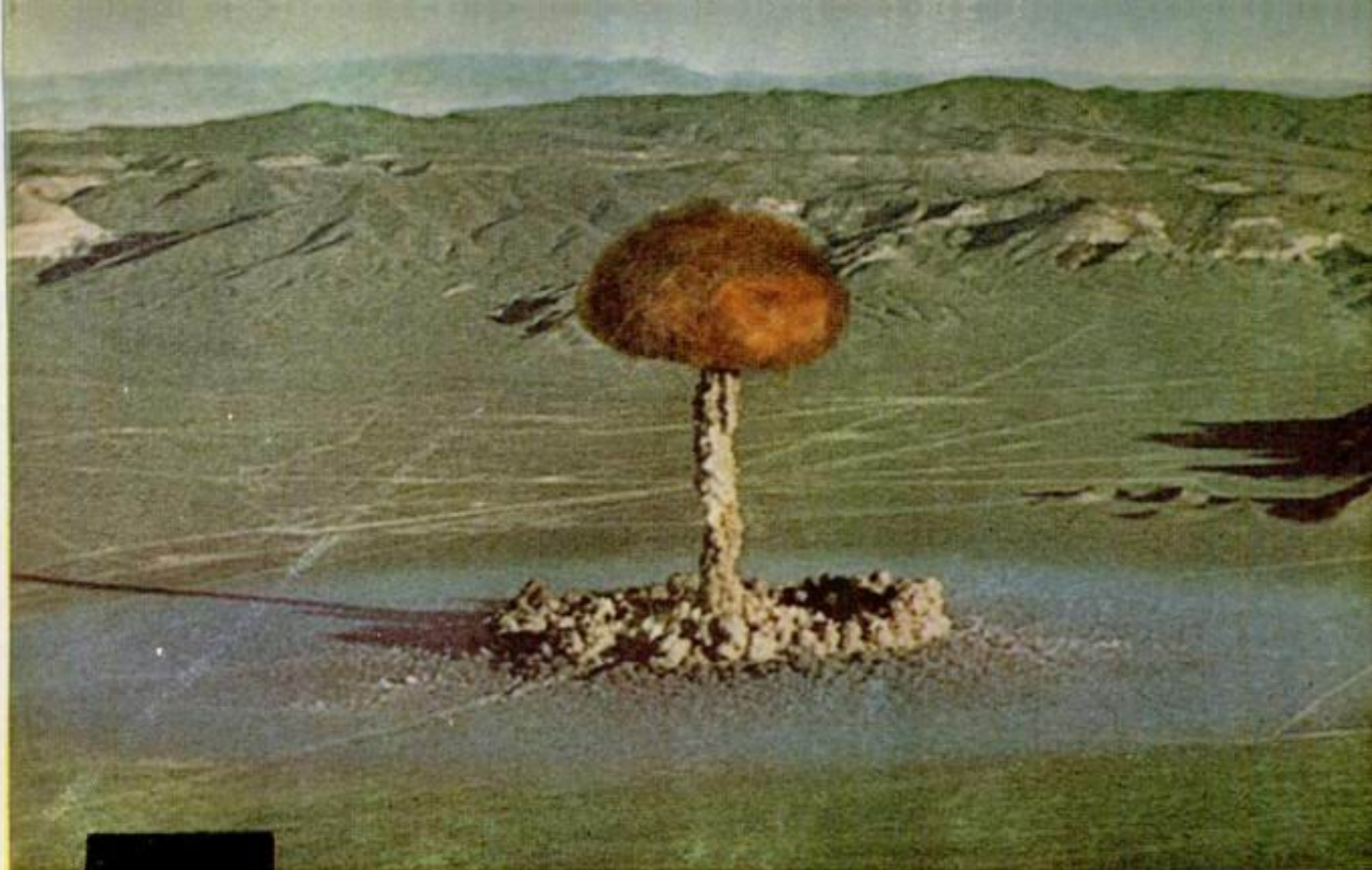
WHAT'S AHEAD IN TV--

an exclusive interview with ALLEN DU MONT

**THE OWNERS REPORT ON THE
DODGE** *By Floyd Clymer*

How to Motorize a Wheel Chair

Material, authorized by the publisher



Atomic Energy Commission, Nevada Proving Ground photo

Blue shock wave spreading from A-bomb tells scientists of densities and temperatures aloft

THE SKY UNFOLDS ITS MYSTERIES

By Thomas E. Stimson, Jr.

LIKE SHREWD EXPLORERS who gather in advance every bit of information about a new region, research teams now are probing the upper air with every available tool.

They are preparing for the day when we'll travel to the outer fringes of the atmosphere and look out on cold, empty space.

Already the scientists know many of the conditions that pioneer explorers of the upper air will encounter.

There's the band of poison air 12 to 20 miles above the earth that would be fatal to anyone who breathed it. It would be lethal, if compressed for breathing, because of its high percentage of ozone or heavy oxygen.

There are the invisible clouds that you can look right through, 60 to 400 miles up. Ordinary light passes through the clouds; most radio waves are reflected from their surfaces.

And hundreds of miles up, eerie ghost winds blow 1000 miles per hour in air so thin these hurricane gales wouldn't even ruffle your hair.

Most important of all from the standpoint of staying alive is the lack of pressure and warmth. It's true that the temperature 500 miles up is calculated to be 4000 degrees

Crew inflates "Moby Dick" balloon that will carry instruments and transmitter to altitude of 20 miles

Air Force photo



EXOSPHERE

500 MI.

600 MI.

SPEED OF ROCKETS NOW ON DRAWING
BOARDS APPROACHES THE VELOCITY
OF ESCAPE FROM THE EARTH

400 MI.

RADAR CONTACT WITH MOON

300 MI.

GUNSHOT INAUDIBLE
THREE FEET FROM EAR

200 MI.

WHAT MAN KNOWS ABOUT THE ATMOSPHERE

100 MI.

HIGHEST TWO-STAGE ROCKET

ROCKET-SKIN TEMPERATURE
DEPENDS ON SOLAR RADIATION

50 MI.

MOST METEORS, SMALLER
THAN PEAS, ARE
CONSUMED BY FRIC-
TIONAL HEAT

HIGHEST ONE-
STAGE ROCKET

HIGHEST ALTITUDE FOR EX-
PERIMENTAL ANIMALS
CARRIED BY ROCKETS

25 MI.

POWER OF RECIPROCAT-
ING ENGINE FALLS TO
ZERO
BLOOD BOILS AND
BODY INFLATES FROM
LACK OF PRESSURE

NOCTILUCENT
CLOUDS

20 MI.

SOUNDING
BALLOONS

15 MI.

WEATHER
BALLOONS

10 MI.

5 MI.

TROPO-
SPHERE

HIGHEST FLIGHT
OF MAN

MOUNT EVEREST

EARTH

WIND—M.P.H.

TEMP.—F.

CUMULUS CLOUDS

CIRRUS CLOUDS

NACREOUS CLOUDS

"D" REGION

"E" LAYER

"F1" LAYER

400-1000

320

70

20

80

+59°

-67°

+170°

-28°

800 MI.

900 MI.

1000 MI.

EXOSPHERE

EXOSPHERE CONTAINS SINGLE SCATTERED MOLECULES AND ATOMS OF AIR

INDIVIDUAL ATOMS BOUNCE OUTWARD BY COLLISION, ARE PULLED BACK BY GRAVITY; A FEW ESCAPE INTO SPACE

PROPOSED ORBIT FOR SATELLITE VEHICLE

ELECTROMAGNETIC RADIATIONS FROM SUN

LONG RADIO WAVES REFLECTED BACK INTO SPACE

HEAT AND LIGHT REACH SURFACE

DANGEROUS ULTRAVIOLET RADIATION IS ABSORBED BEFORE REACHING SURFACE

SOFT X-RAYS HELP CREATE IONOSPHERE

GAMMA RAYS ACT ON UPPER ATMOSPHERE

MICRORADIO WAVES REACH SURFACE

PRIMARY COSMIC RAYS BREAK INTO SHOWERS

OUTER SPACE CONTAINS POSSIBLY ONE PARTICLE OF MATTER PER CUBIC CENTIMETER

FRINGE AREA

AURORA POLARIS, 40 TO 600 MILES

"LIGHT OF NIGHT SKY" FROM ATOMIC ACTIVITY

JET STREAM WINDS UP TO 200 M.P.H. AT ALTITUDE OF EIGHT MILES

UP TO +4000°

"F2" LAYER

IONIZED LAYERS ("INVISIBLE CLOUDS") CREATED BY SUN, REFLECT SOME RADIO WAVES

EXOSPHERE—The outermost or fringe area of the atmosphere is occupied only by gaseous particles.

IONOSPHERE—In this layer some particles are broken down into ions and free electrons by absorption of ultraviolet radiation from sun. Temperatures up to 4000 deg. F.

STRATOSPHERE—Contains slightly less than one fourth of atmosphere by weight. High-temperature region in upper portion caused by concentration of ozone.

TROPOSPHERE—Area of life. It contains about three fourths of the atmosphere by weight.

Artist's impression of jet B-47 as an airliner. Boeing may add fuel tanks under the wings and convert 600-m.p.h. bomber into a transport



Commute by Jet

By Aubrey O. Cookman, Jr.

I WONDER WHAT it's like?" How many airline passengers, looking out the window at jet fighters and bombers "whooshing" by in the distance, have asked that question? And, in the same breath, "how soon will I be doing it?"

Those jets, many with wings swept back like wild geese in flight, are lifting the curtain on new and almost staggering vistas of speed in transportation. A generation of travelers, just becoming accustomed to the time schedules of conventional planes, have a jolt in store for them. Not tomorrow, but unquestionably jets will begin scheduled operations by 1952.

Every major advance in transportation has changed man's life by telescoping time and distance. Ox cart—horse and buggy—locomotive—automobile—piston-engine planes—and now, jets. Everything points toward as big a change from today's airplanes to tomorrow's jets, and perhaps rockets, too, as from the horse and buggy to the automobile.

At already-achieved jet-propulsion speeds any corner of the world will be accessible in a matter of hours. Before this century ends, an air traveler leaving London to spend a week end in New York may be able to say: "Well, goodbye. I'll

arrive in New York City 25 minutes ago."

Confusing? Yes, but perfectly possible with jet speeds. Racing with the sun he actually will arrive in New York 25 minutes earlier than he left London. Breakfast and dinner at places 5000 miles apart, like Istanbul and Brooklyn, won't be an exciting enough travel event to warrant space in the newspaper.

Today's air-traffic rules will be obsolete. Jets, with their terrific rate of fuel consumption, can't waste valuable time being stacked over airports waiting until there is space for them to come in and land. A jet-engine transport the size of the DC-6 would burn four times as much fuel per hour in a holding stack as does the DC-6.

They'll be quieter than today's piston-engine airliners, will vibrate much less and fly much higher. There will be many difficulties to overcome, too, before this high-speed newcomer can be absorbed into the world's transportation system, but we're not talking of fantasy. Two pure jet liners are already here, and flying.

Heading the parade, as the world's first passenger-carrying turbojet, is Britain's de Havilland Comet. Still experimental, it whipped from London to North Africa and back, nearly 3000 miles, at an average speed



de Havilland Aircraft Co. photo

Engines only 53 inches in diameter are almost completely buried within the Comet's relatively thin wing

above 450 miles an hour. Since then it has cruised at nearly 500 miles an hour, approximately 200 miles an hour faster than today's fastest commercial planes.

Just as the first motor cars looked much like the buggies they were to replace, the Comet has few radical "body" changes. Not revolutionary in appearance, the plane is beautifully streamlined. An American Air Force officer, watching it execute a tight 60-degree bank, said, "We haven't a fighter any cleaner than that baby!"

The four power plants are buried in a thin wing, only moderately swept back. A stubby undercarriage, made possible by the absence of propellers, allows the plane to be closer to the ground—simplifying loading and unloading.

Jets operate most economically at great altitude, so the Comet will fly as much as possible at 40,000 feet—nearly twice as high as present air travel. This meant building a

fuselage for a pressure differential of over eight pounds per square inch. Instead of rivets, surfaces are bonded together with a resin-and-plastic combination, applied with great heat and pressure.

The 105,000-pound de Havilland liner will be able to operate from present, average-size airports. For fuel it is using a 99-percent kerosene and one-percent oil combination, used safely in British fighter craft for several years. The plane's "Ghost" engines, the first jets approved for public transportation, set the present world's altitude record of 59,446 feet in a fighter. Comets will normally operate with a crew of four and 36 passengers.

The world's other flying turbojet transport, Canada's Avro jetliner, is lighter than the Comet and intended for shorter, 200 to 800-mile routes. In rate of climb and at level speed the 50-passenger Avro outdoes two

(Continued to page 262)

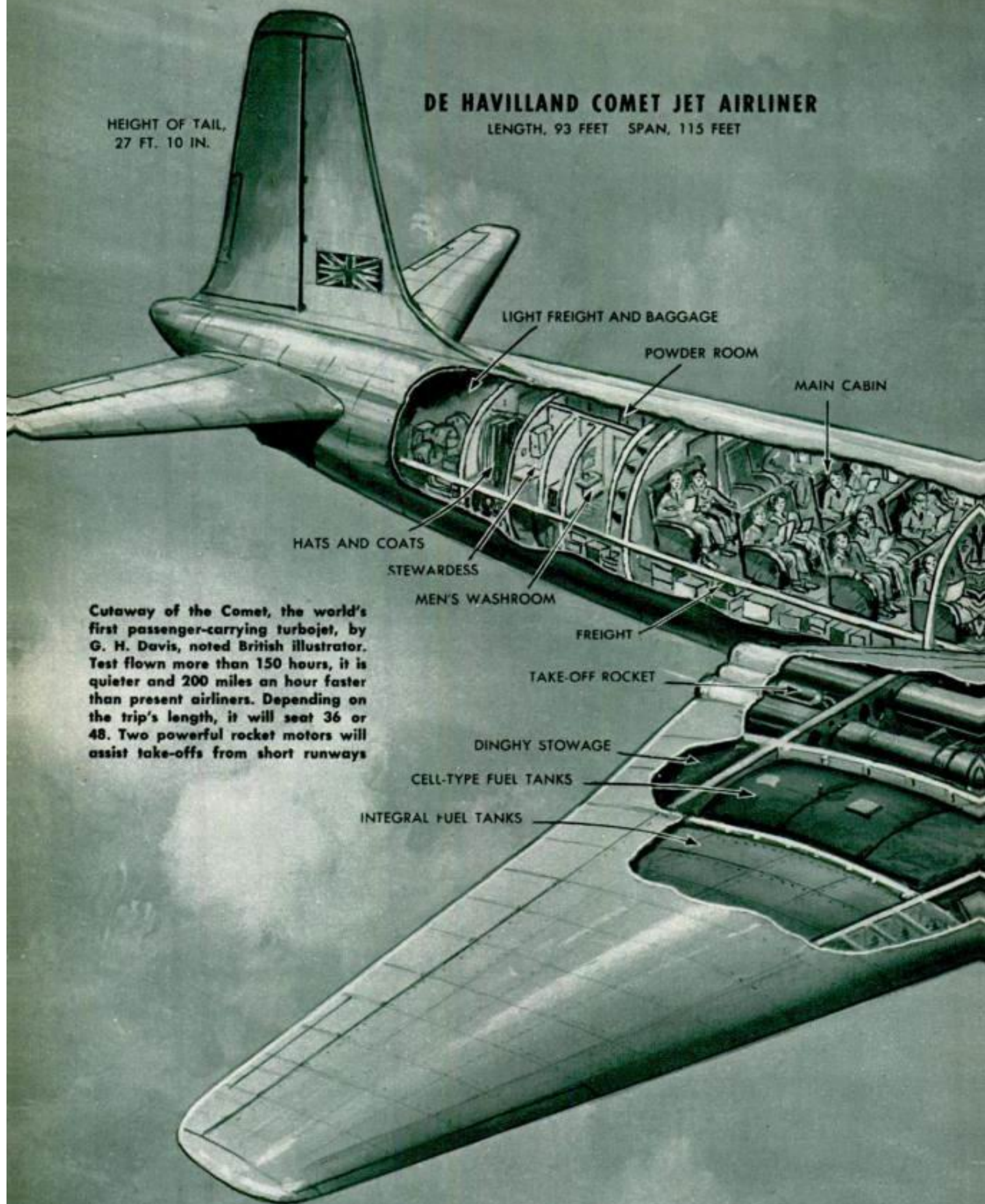
Built for trips up to 800 miles, Canada's Jetliner cruises at 450 m.p.h. It is expected to be in service in 1952



HEIGHT OF TAIL,
27 FT. 10 IN.

DE HAVILLAND COMET JET AIRLINER

LENGTH, 93 FEET SPAN, 115 FEET



Cutaway of the Comet, the world's first passenger-carrying turbojet, by G. H. Davis, noted British illustrator. Test flown more than 150 hours, it is quieter and 200 miles an hour faster than present airliners. Depending on the trip's length, it will seat 36 or 48. Two powerful rocket motors will assist take-offs from short runways

LIGHT FREIGHT AND BAGGAGE

POWDER ROOM

MAIN CABIN

HATS AND COATS

STEWARDESS

MEN'S WASHROOM

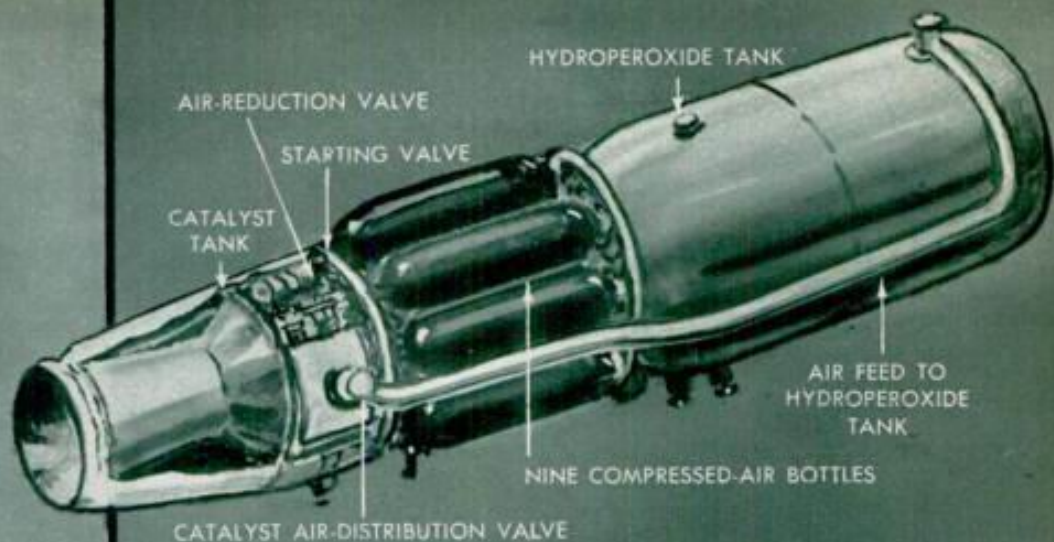
FREIGHT

TAKE-OFF ROCKET

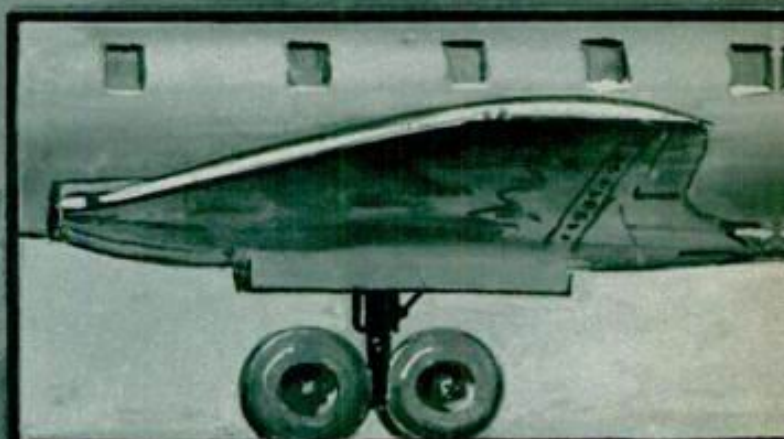
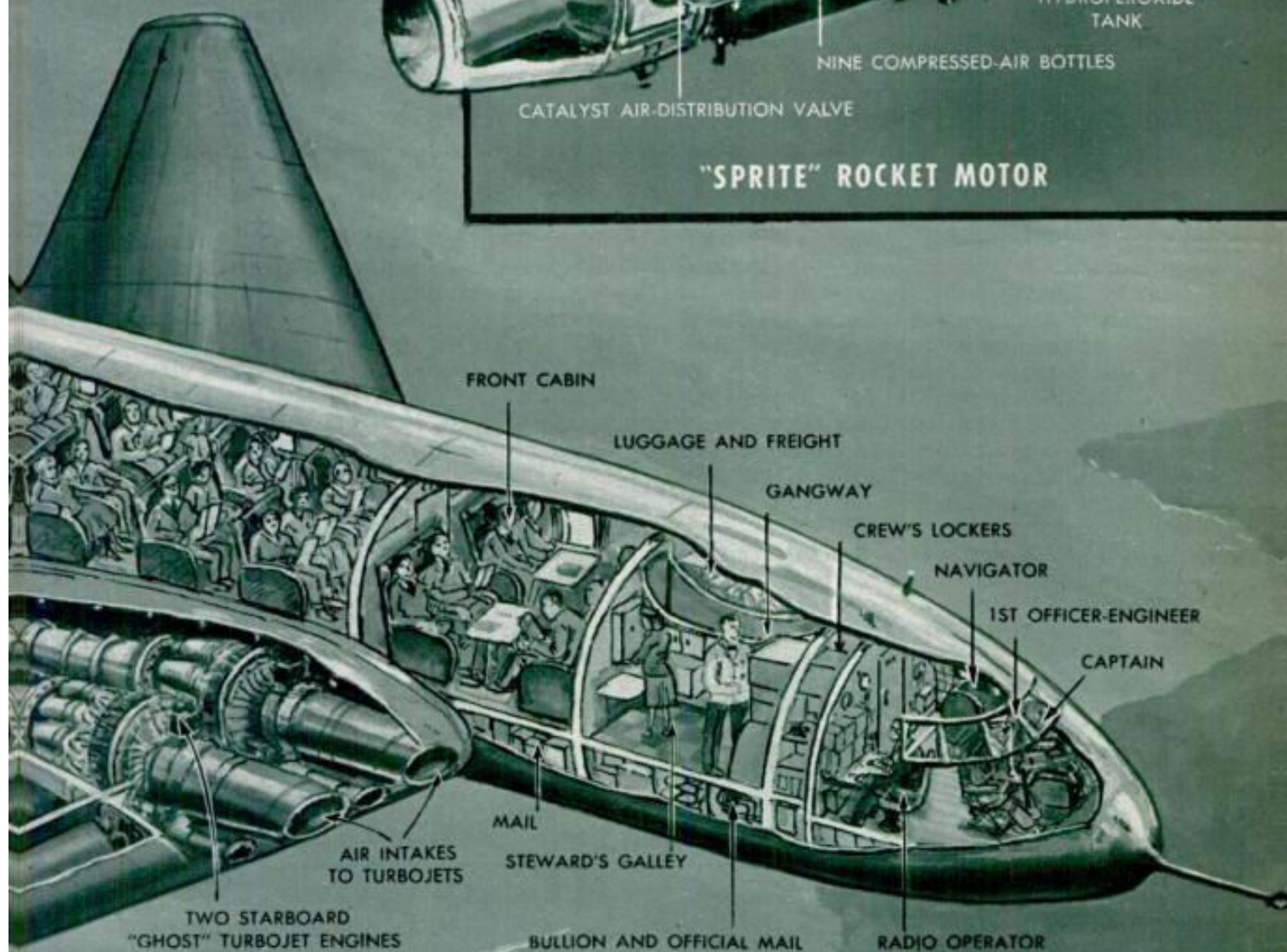
DINGHY STOWAGE

CELL-TYPE FUEL TANKS

INTEGRAL FUEL TANKS



"SPRITE" ROCKET MOTOR



DOUBLE TANDEM LANDING GEAR



GIANT twin-hull flying boats, weighing 250 tons or more, may be the amphibious craft for beach landings on hostile shores in future wars. Such huge seaplanes could carry 1000 men plus equipment, would fly at speeds approaching the top speeds of the fastest land aircraft, and upon approaching a hostile shore would land in the water, taxi up to the beach and open armored bow doors to discharge their troops.

If submarines make the seas too dangerous for ordinary shipping, the twin-hull flying boats envisioned above will have to be built, says Ernest G. Stout, head of naval aircraft research for the Consolidated-Vultee Aircraft Corporation. In fact, he says, the aircraft industry could start construction of them at any time that the need arises. All major problems in large flying-boat construction have already been given study.

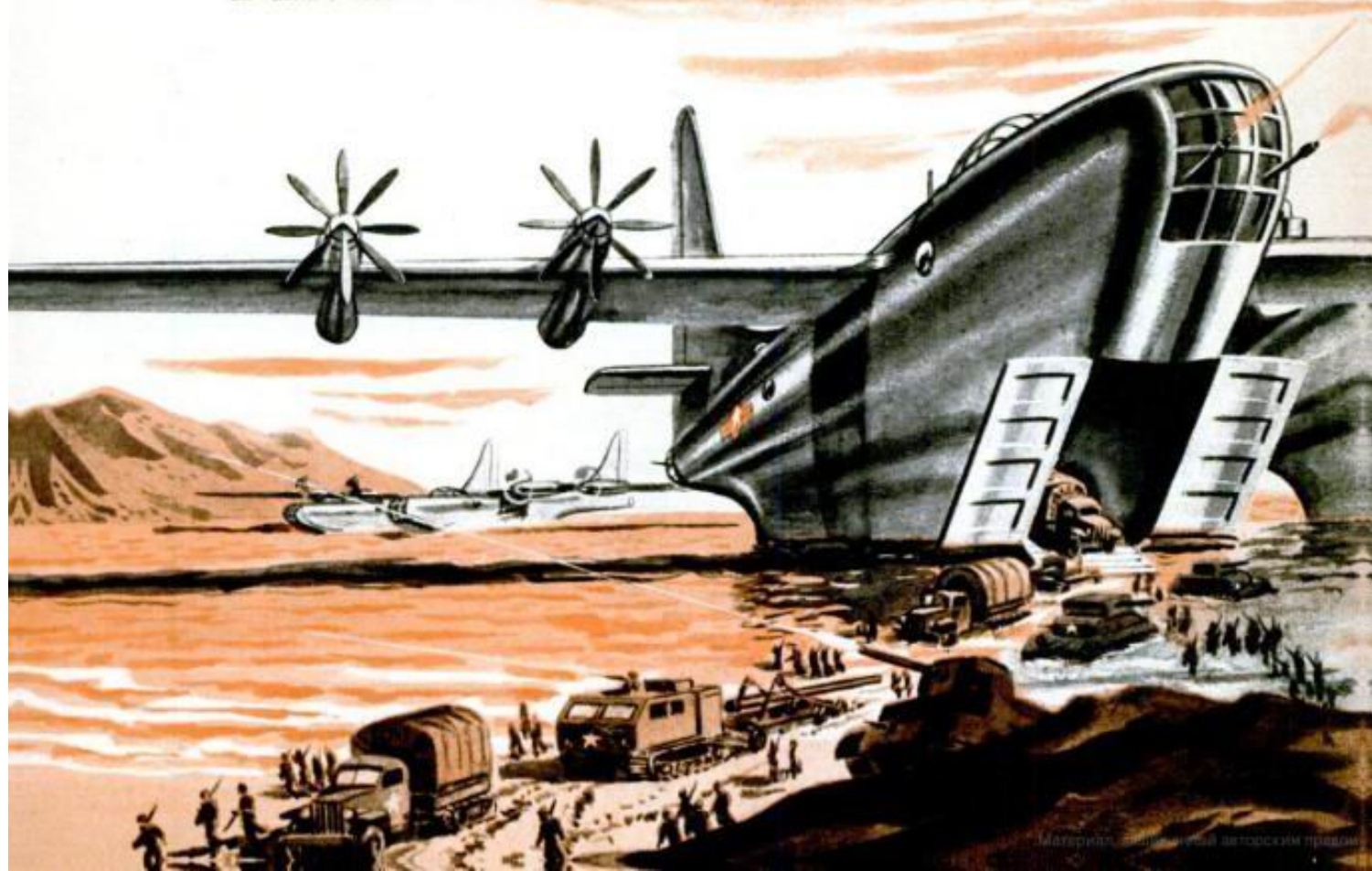
Flying-boat research was practically abandoned during the last war because of the emphasis on land planes. Since then designers have



from **MODEL** to **MONSTER**

By Ewart Thomas

Research for aerial assault boats that will carry up to 1000 men is being carried on with flying miniatures weighing as little as 123 pounds. Above and below are an artist's idea of how tomorrow's 250-ton amphibians will "hit the beach"



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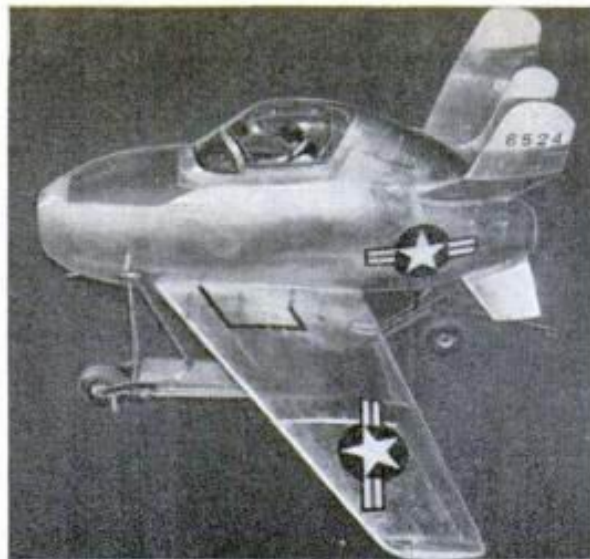
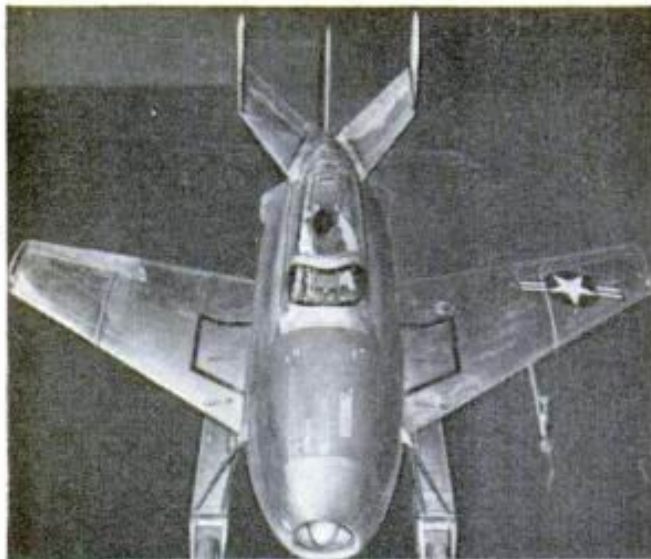
WRITTEN SO YOU CAN UNDERSTAND IT

U.S. AIRCRAFT, GREAT BRITAIN, No. 410228

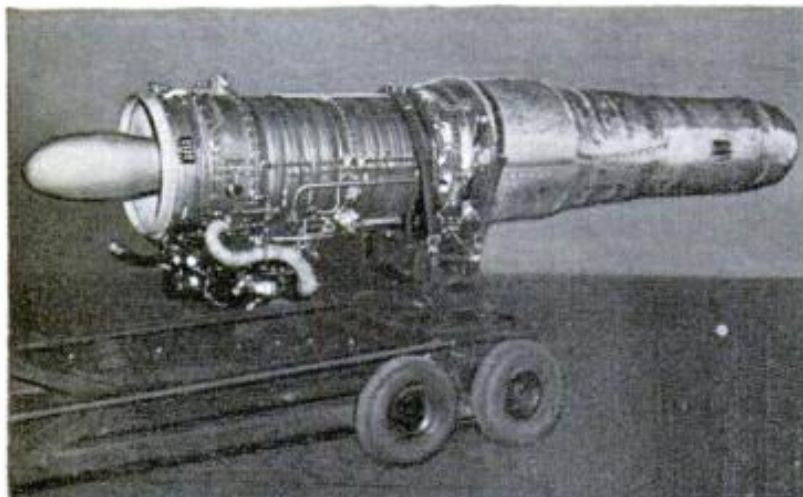


BEACHHEAD FLYING BOAT

Page 133



Above, odd-shaped tail assembly of the stubby XP-85 was necessary to provide maximum stability and still fit in bomb bay's tight space

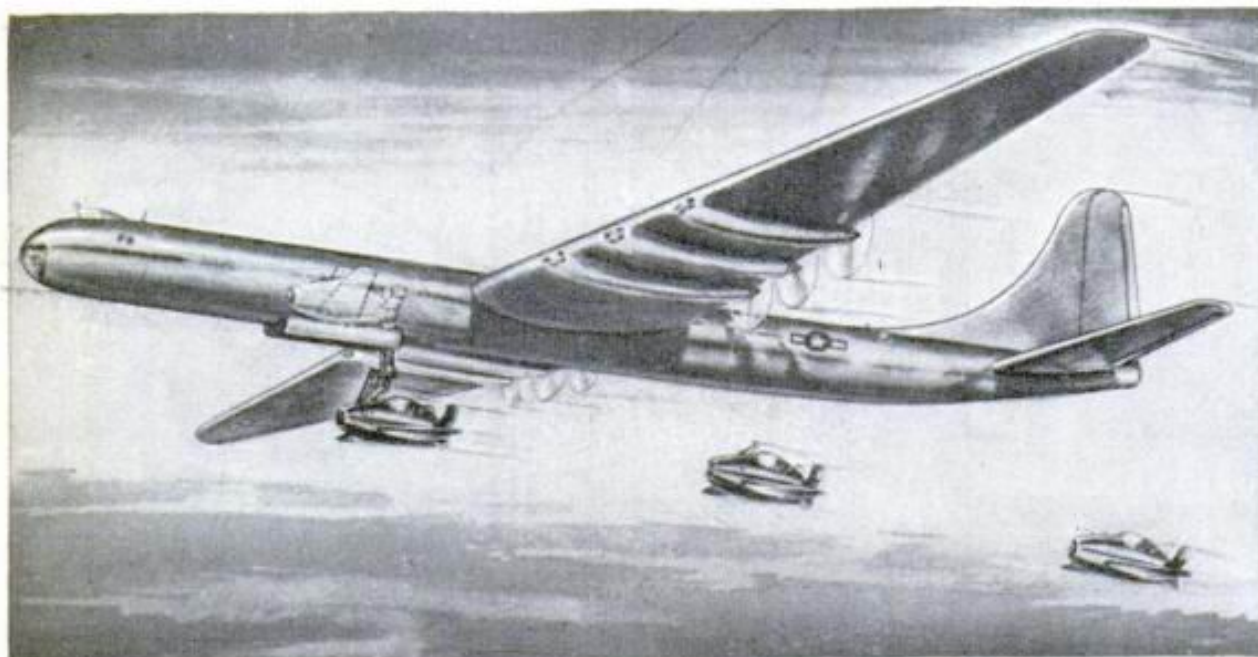


U. S. Air Force photos

Frontal area of XP-85 Westinghouse jet engine, above, offers least wind resistance and makes speed of over 600 miles an hour possible. Below, "parasite" fighters will be lifted in and out of bomb bays by a mooring hook. The McDonnell-built plane has no landing gear

BOMBER CARRIES JET FIGHTERS

One of man's most spectacular dreams, fighter planes that ride to and from battle inside long-range bombers, has become a reality. Called the XP-85, the U. S. Air Force's tiny jet "parasite" travels faster than 600 miles an hour. Unlike other fighters, it will only have to carry enough fuel to fly during the brief moments of actual combat, and none for the long trips to and from the target. The deadly mite is 15 feet long. The wings, spanning 21 feet, fold so that a mooring hook can bring the plane in and out of the bomb bay.



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**BOMBER CARRIES
JET FIGHTERS
PAGE 112**



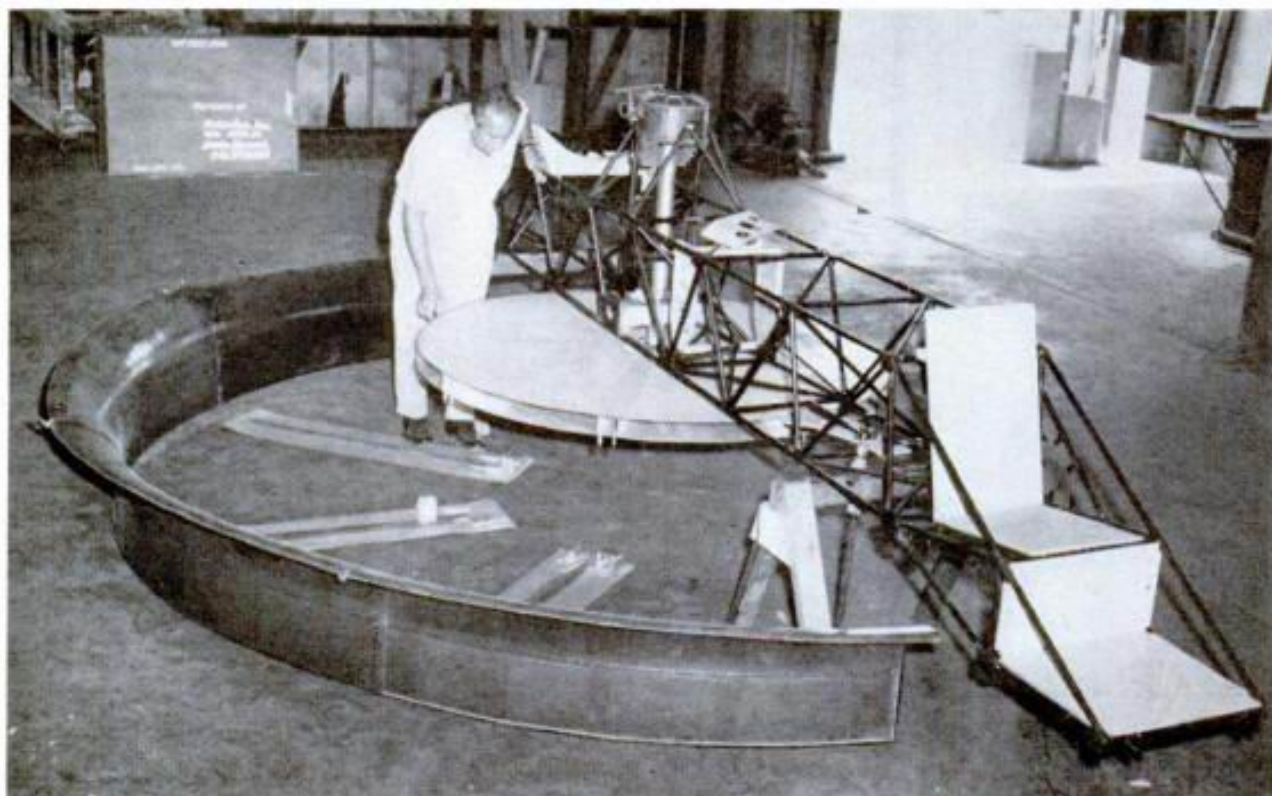
WORLD'S SAFEST PLANE?

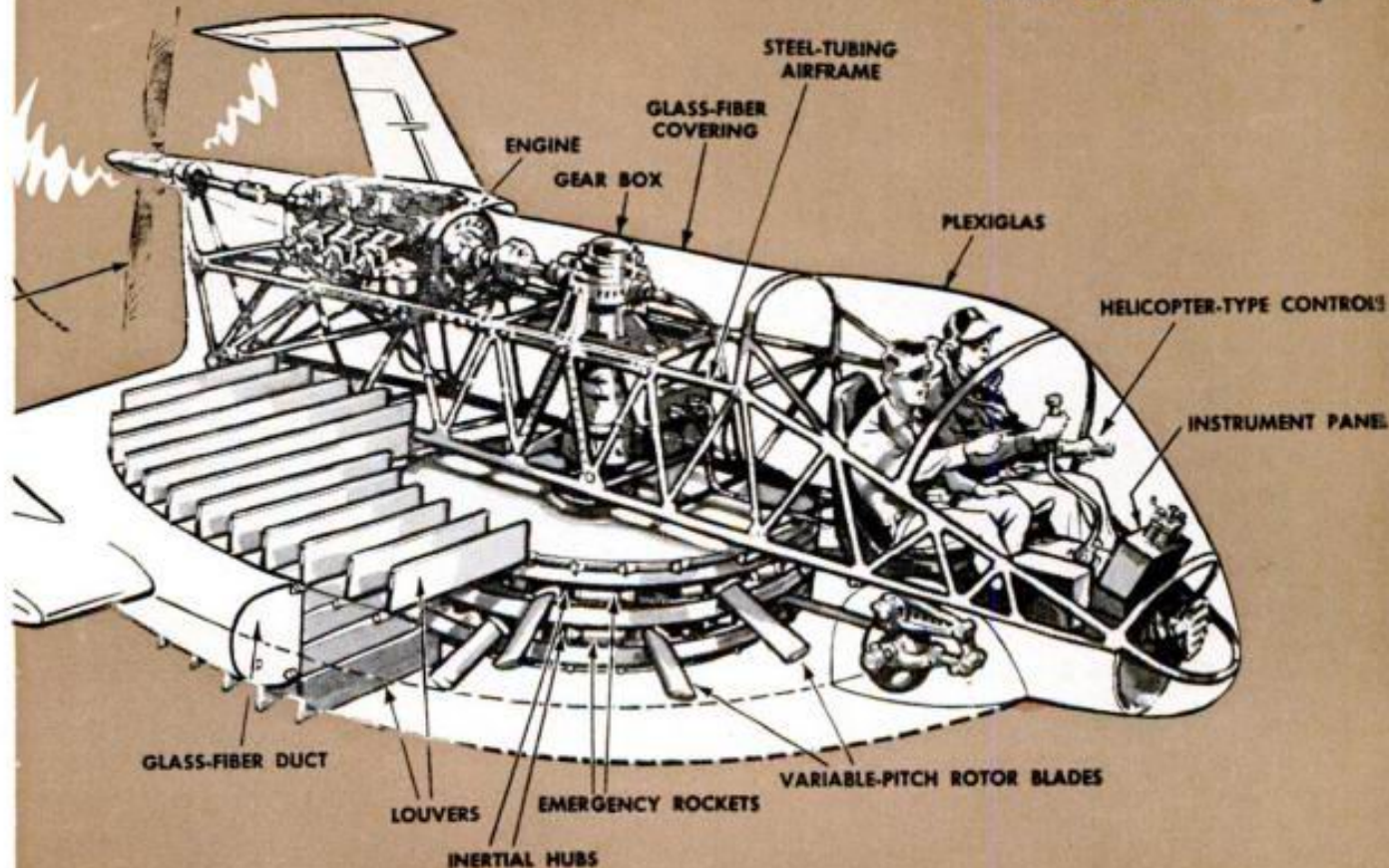
By Thomas E. Stimson, Jr.



It promises to ease you back to

ROTAVION PROTOTYPE is partially shown in mockup of some of its parts, including portion of duct fairing, one of inertial hubs, gearbox, steel-tubing fuselage and pilot's seat. Production model will have twin seats





earth, no matter what the trouble

IF 40 AIRCRAFT ENGINEERS pooled their know-how to design a safe aircraft for the general public, what would it look like?

It would look like the Rotavion, shown on these pages for the first time.

The Rotavion is the spare-time project of several dozen airplane engineers and aircraft shop men. All are employed in California's aircraft and missile factories and they have been getting together nights and week ends to build what they believe is the world's safest aircraft.

What they've come up with is a machine unlike anything ever seen before.

Basically it is a ducted fan, a vertical-takeoff-and-landing craft. At the same time it is a fairly conventional airplane that can cruise at 175 m.p.h. in level flight.

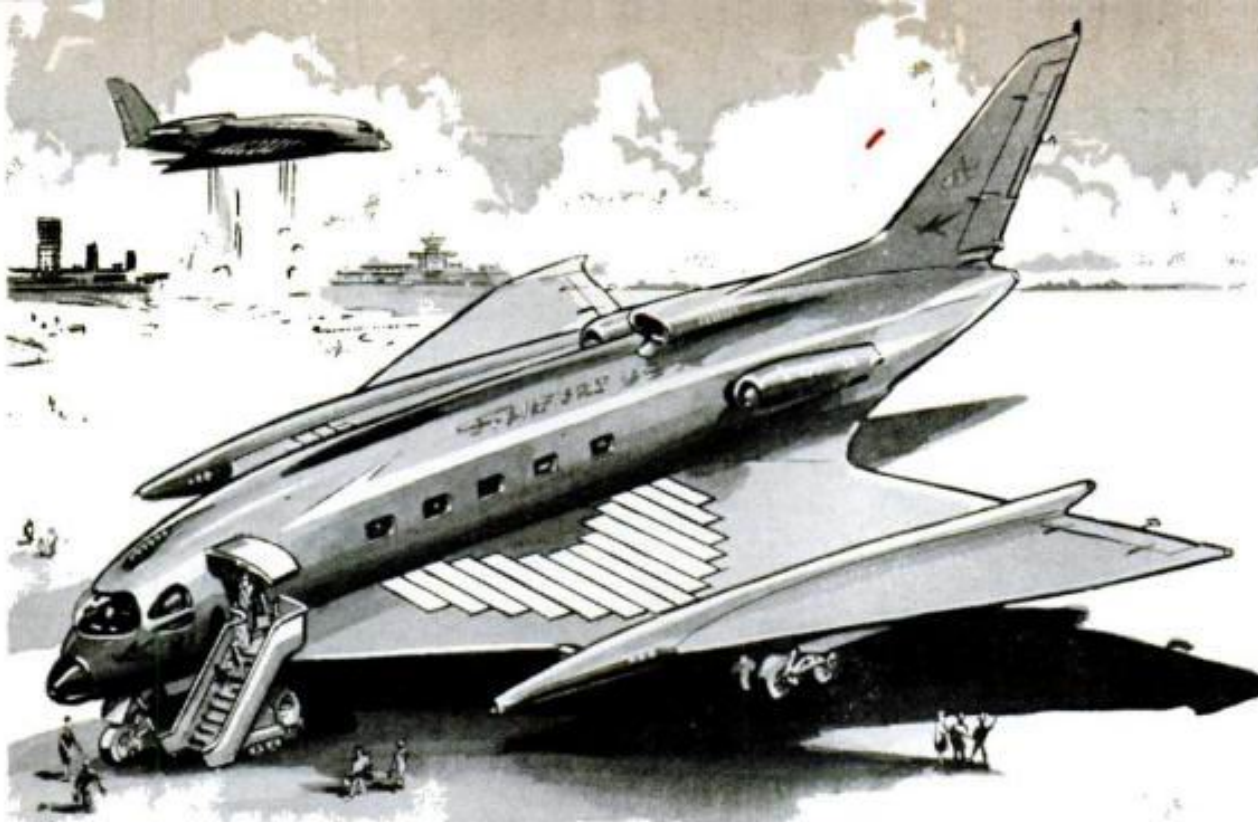
It is intended to stay out of trouble even with a dead engine. It involves no new, untried principles.

The Rotavion XR-62 (for experimental rotor, 62nd design study) has two contra-rotating sets of rotor blades inside a circular duct that is 13 feet in diameter. Across the top of the duct are louvers that are hinged to close in a forward position;

across the bottom are other louvers hinged to close toward the rear. Mounted above the duct is a fuselage containing the cockpit and a 260 hp. Lycoming engine that is geared to the rotor assembly. The engine also is connected permanently to a variable-pitch propeller that is mounted between the twin tail groups.

Controls are something like those of a helicopter. To fly the Rotavion the pilot runs up the engine with the rear propeller set at zero pitch, then he increases the collective pitch of the rotor blades to create lift and the machine climbs straight up at the rate of 600 feet per minute.

After rising above any nearby obstacle the pilot advances the propeller's pitch control to provide forward thrust and the machine begins to move ahead. The louvers above and below the duct begin to close, converting the duct into an oddly shaped but nevertheless efficient airfoil. Within a few seconds the plane is traveling faster than its stalling speed of 40 miles per hour. The pilot disengages the rotor clutch so that all power is delivered to the propeller and from then on flies the craft like an ordinary airplane. Range is 400 miles.



JETLINER VERSION of Rotavion might look like this, fly 400 miles an hour, yet be able to take off vertically

The pilot can make a transition back into VTOL configuration for a vertical and slow descent to the ground at any time. And, as with a helicopter, he can hover motionless, rotate the craft on its own axis or travel backwards or sideways.

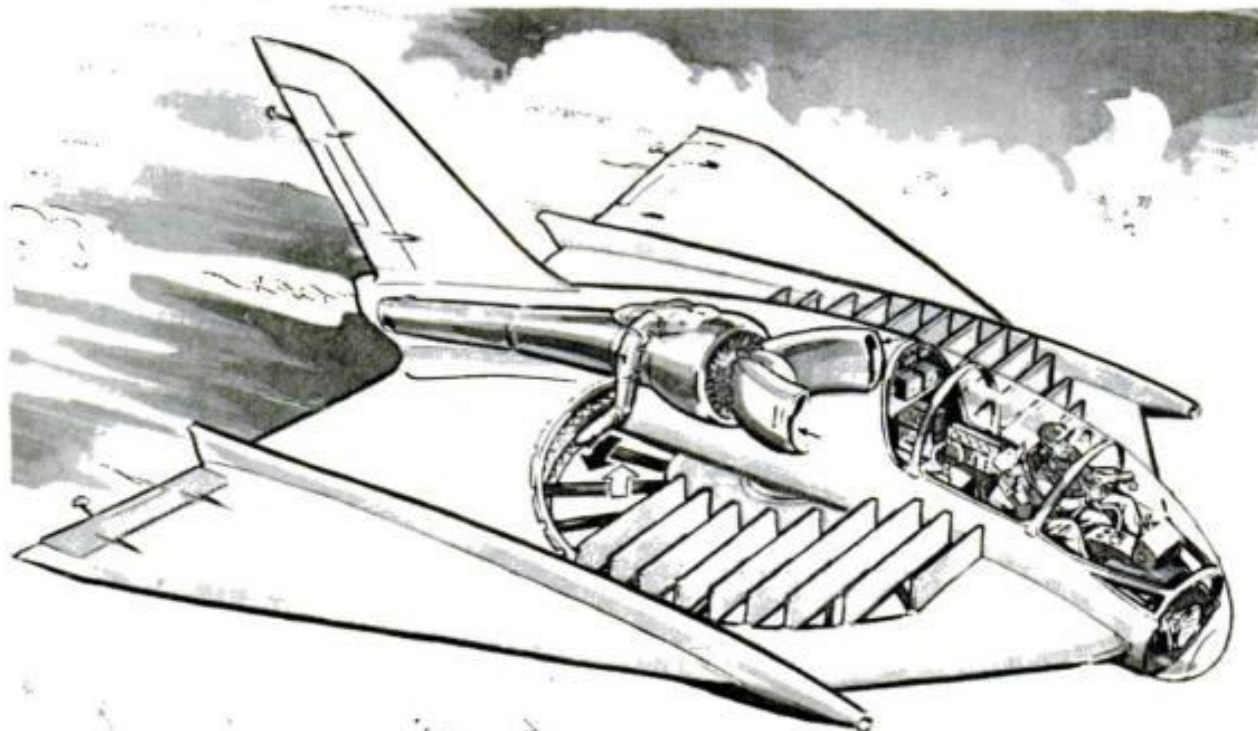
Or, with the louvers closed and all power applied to the propeller, the pilot can use the craft exactly like any other airplane. He can take off from a short runway and make a normal, airplane type of approach and landing, at a speed under 50 m.p.h.

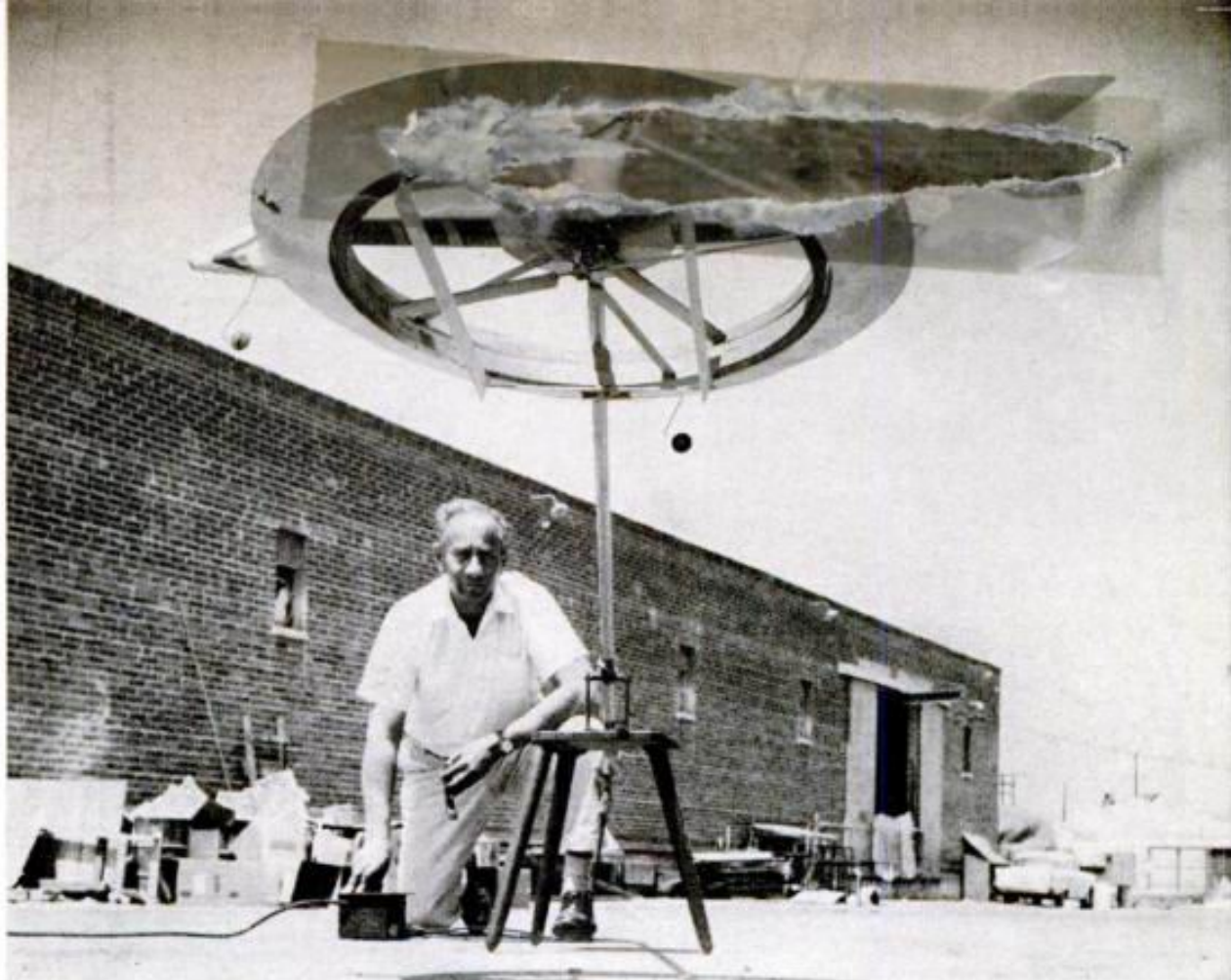
The Rotavion is 23 feet long, 22 feet wide and 8 feet high. With two people and 110 pounds of baggage on board it has a takeoff weight of 1850 lb. Its hovering ceiling is 4300 feet away from ground effect. The craft is equipped with retractable nose wheel and two rear landing wheels plus small skids to prevent accidental damage to the lower louvers.

The duct, stub wings, louvers and tail assemblies are of glass-fiber-covered honey-

(Continued to page 216)

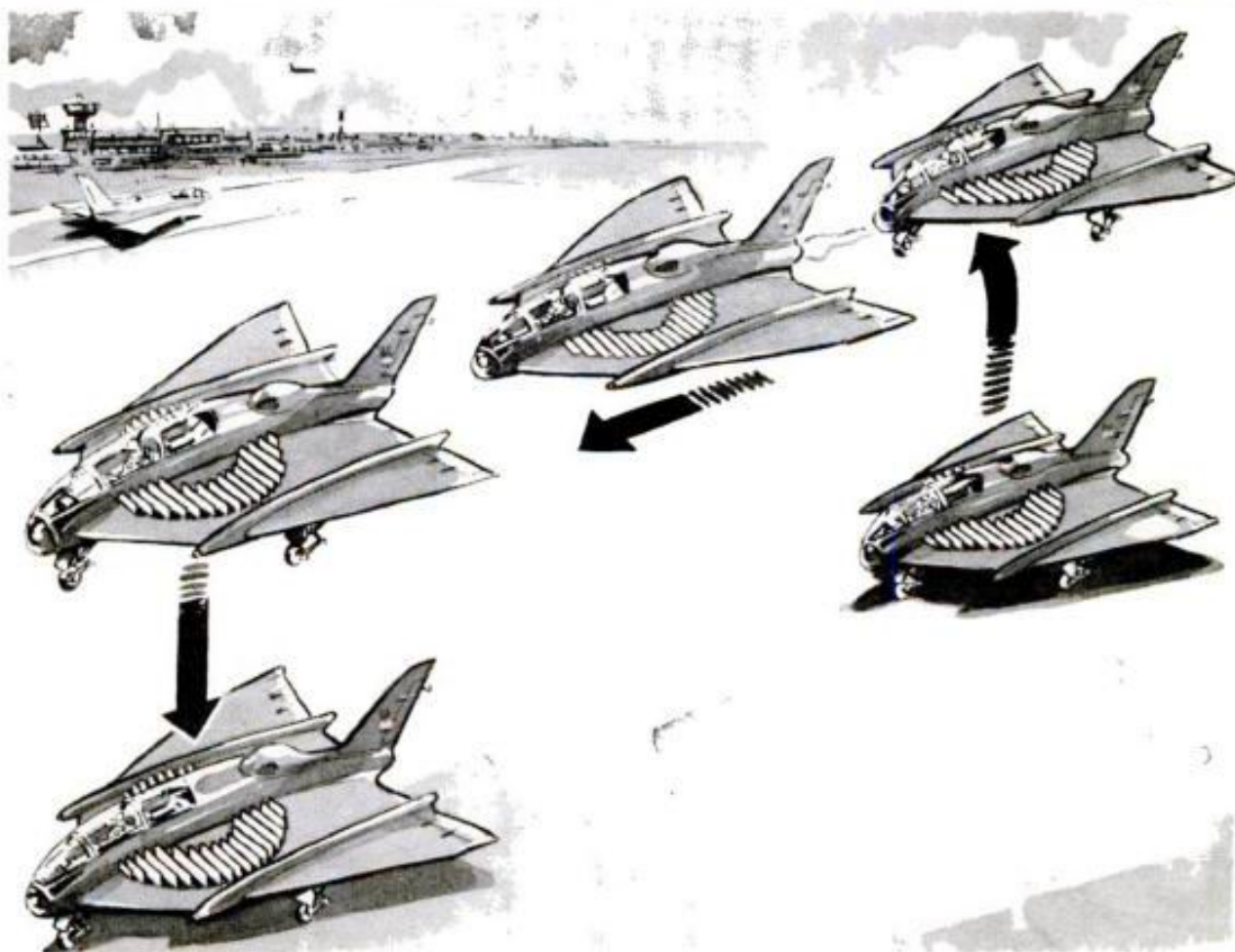
CUTAWAY SKETCH of jet Rotavion shows how air from turbine would drive rotor blades from perimeter of duct





BEN KAUFMAN, spark plug behind Rotavion, tests early scale model. Though crude, it proved craft's principles

SEQUENCE DRAWING shows vertical takeoff, cruise and vertical descent. Louvers are closed during cruise



AUGUST 1961

PREVIEW: The '62 Cars

POPULAR MECHANICS

AUGUST, 1961 • 35 CENTS

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WILDERNESS ?
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Shelters
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MAR. 1968
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Amazing New Glass Cuts Glare
With the Turn of a Knob

**PUT A ROLL BAR
IN YOUR CAR!** Page 77

ALSO What Owners Think of '68 Chevelle

How to Sell an Invention to Detroit

Driving Honda's New Little Car

Dan Gurney Tests the AMX

Saturday Mechanic:
Power Brakes

Drivin' With Dan
Auto Clinic

*THE
CONCORDE*

First of the SSTs

Giant Color Cutaway
Page 111

THINGS TO MAKE

Sidewalk Rickshaw

Weekend Projects

Wall-Hung Desk

Baritone Guitar

Enlarger Stand

Trailer for
Garden Tractor

HOW TO Buy a House
Without Getting Hurt

Lay a Hardwood Floor

Choose a Compact Stereo

NOSE POSITIONS

Transparent visor

SUPERSONIC

Nose up
Visor up

Visor jack

Hinge

SUBSONIC

Nose up
Visor down

Visor guide rails

Nose guide rails

LANDING

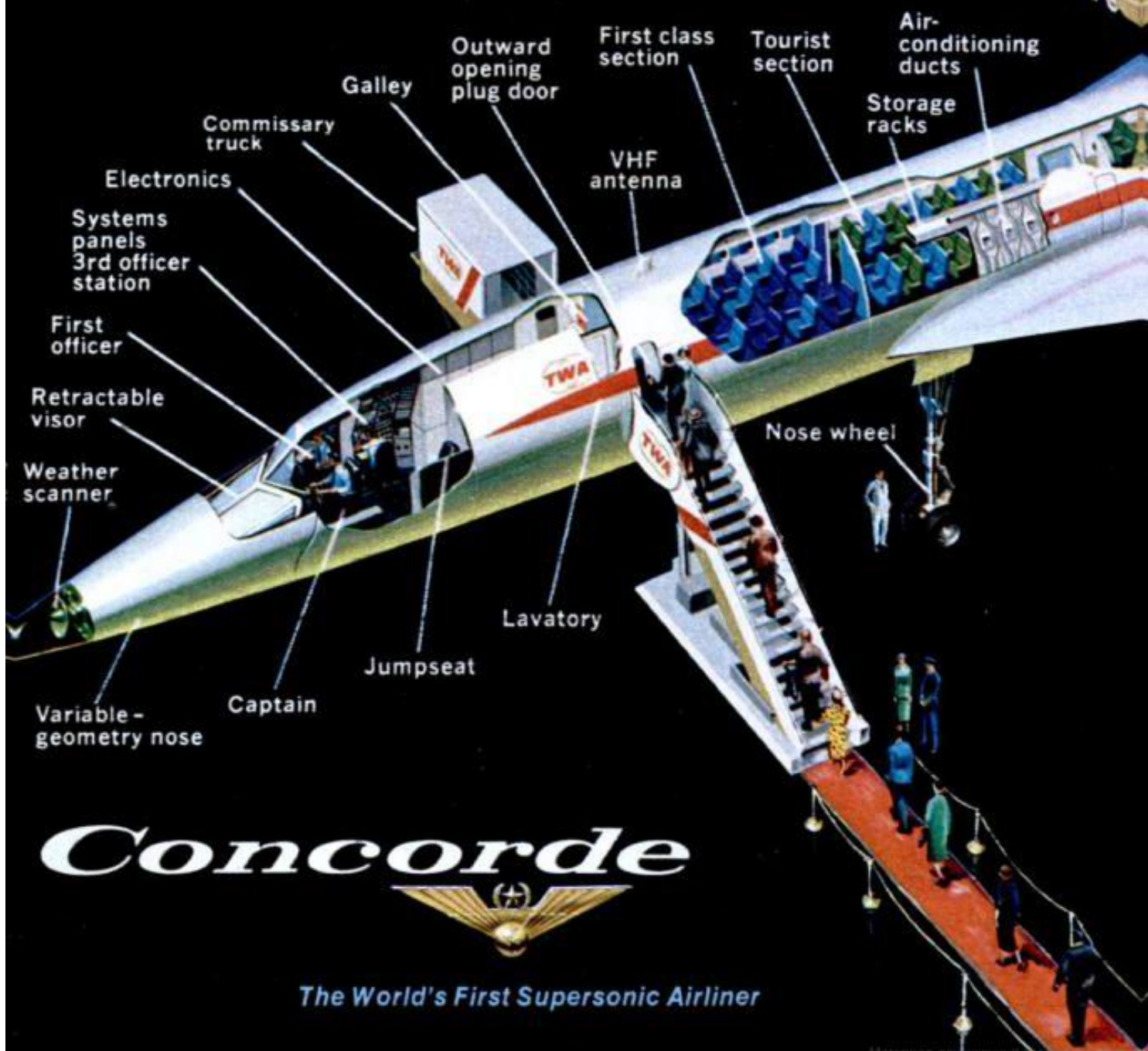
Nose down
Visor down

Hinge

Nose screw jack

THIS is it! This is the Concorde, the first airliner that will offer the thrill of supersonic flight to the average passenger. You, or anyone, will now be able to board this plane and break the forbidding sound barrier, fly at more than twice sound's speed, and streak into a world where no bird has been, nor man either except for that happy breed of military and test pilots. They paved the way so you may follow. Now the limits of flight seem less limited. The Concorde will take you from New York to London in 3 hours and 22 minutes, and no point on earth is more than 12 hours away. Besides supersonic flight, the Concorde offers several other firsts for commercial aviation. It's the first airliner with a delta wing, the first to change its configuration while in flight (see left), and the first jetliner to introduce sound suppressors on its engines.

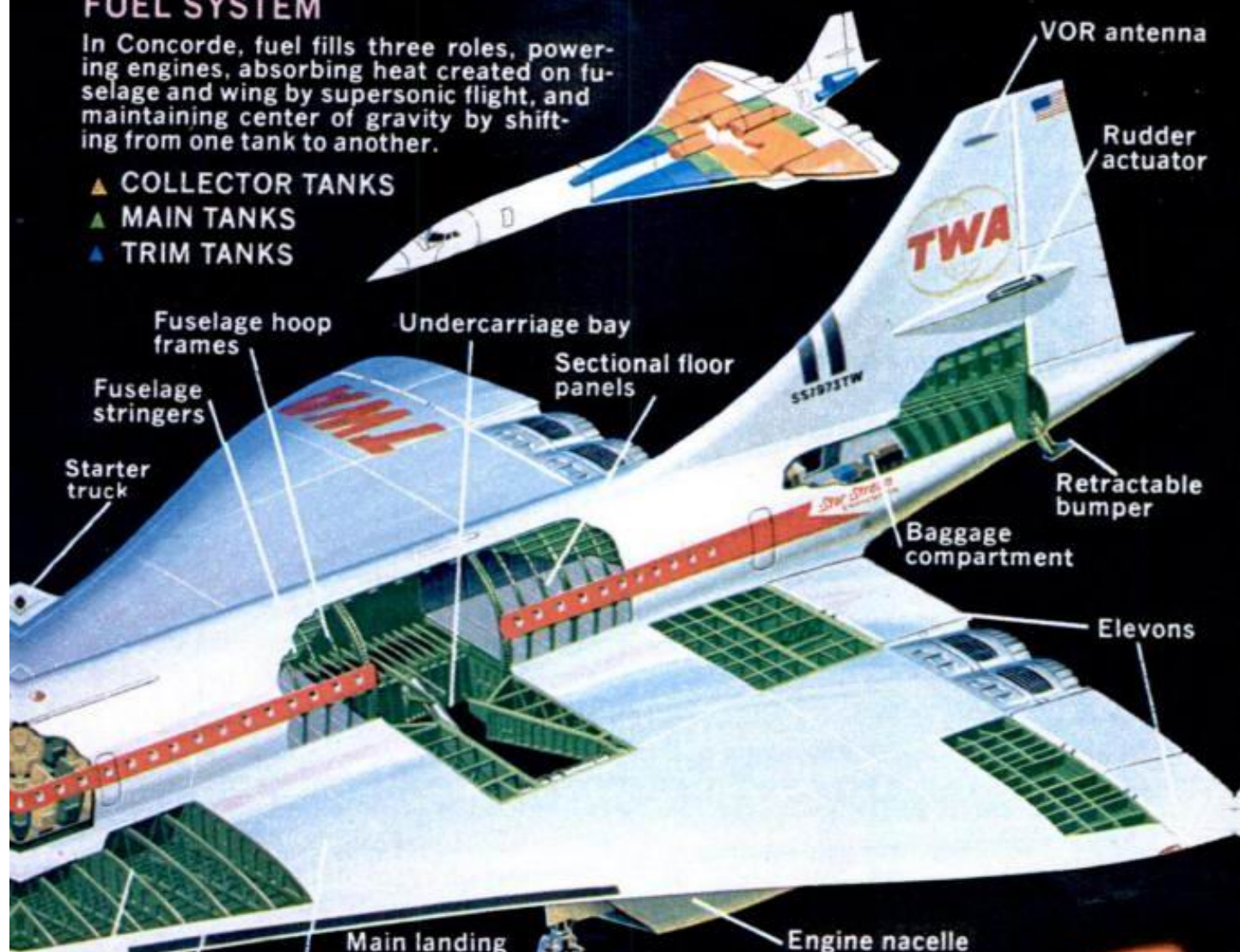
ILLUSTRATION CREATED EXCLUSIVELY FOR
POPULAR MECHANICS
By Fred Wolff, Dale Gustafson, Roger Chapin
and Howard Schafer



FUEL SYSTEM

In Concorde, fuel fills three roles, powering engines, absorbing heat created on fuselage and wing by supersonic flight, and maintaining center of gravity by shifting from one tank to another.

- ▲ COLLECTOR TANKS
- ▲ MAIN TANKS
- ▲ TRIM TANKS

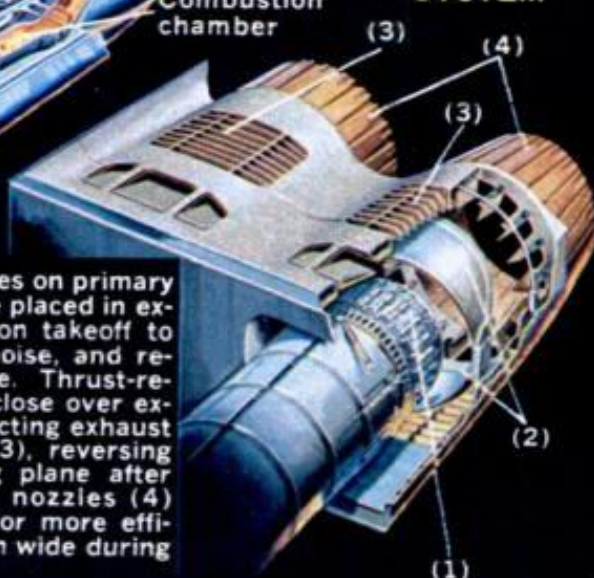


OLYMPUS 593 TURBOJETS
Produce 35,000 pounds of thrust each



Silencer lobes on primary nozzle (1) are placed in exhaust stream on takeoff to reduce engine noise, and retracted for cruise. Thrust-reverse buckets (2) close over exhaust stream, deflecting exhaust through cascades (3), reversing stream and braking plane after landing. Secondary nozzles (4) pinch in on takeoff for more efficient thrust, and open wide during supersonic cruise.

EXHAUST SYSTEM



Good Cars You Can't Buy Here

Page 108

POPULAR MECHANICS

NOV. 1967
35 CENTS

'TIGER SHARKS'
of the **VIETNAM**
SWAMPS

What's New in
COLOR TV?

50 GREAT IDEAS
FOR YOUR **FAMILY
LEISURE CENTER**
SPECIAL 24-Page Tear-Out SECTION

**Time
Bombs
Full of Oil**

100 Sunken Tankers
That Can Pollute Our Beaches

WEEKEND PROJECTS: Seven Christmas Gifts to Make in Your Shop
Getting the Most from a Portable Jigsaw
Build a Cart for Your Shop Vacuum • Gordon Johncock Tests the Javelin

'Tiger Sharks' Strike In the Vietnam Swamps

The big awkward-looking air-cushion vehicles surprised the Vietcong (and the U.S. Navy) by riding over any terrain at 70 mph, knocking over trees and capsizing enemy sampans.

By Wallace Cloud

THREE ACVs sweep across marshlands, searching out Vietcong terrorists in previously privileged sanctuaries

ON THE WAY to the Plain of Reeds," Mike Vincent said, "the last ACV in the column radioed they thought they had hit a land mine. We didn't stop—we were moving through VC territory.

"Later, we took a look. All we found were some holes in the craft's skin, aft. Nobody was hurt, and there was no structural damage.

"We're not sure it was a land mine, but it takes more than that to stop a skimmer at 60 knots."

That's right. Sixty knots (about 70 mph) across flooded paddies, mud flats mangrove swamps, saw-grass hummocks. ACVs (air-cushion vehicles) can go where even helicopters can't

land. You're down on the ground, churning up spray, carrying 10 or 15 Green Berets and Vietnamese irregulars on the sloping deck. You can plop down anywhere—on hard ground, muck, or water—search sampans and grab prisoners hiding in the reeds—then lift up and streak away.

That's what guys who were there say about the U.S. Navy's odd inland mission to test three Bell SK-5 ACVs, armed with machine guns, in action in Vietnam. Lt. Mike Vincent was executive officer of PACV (Patrol Air Cushion Vehicle) Div. 107. Now a civilian, he works for Bell Aerosystems, builder of the skimmers.

Will hovercraft (as they're also

SURPRISED VC (below) surrender. They had never met anything like ACVs which chased them into swamp

ARTIST'S CONCEPT of newest ACVs (next two pages) in full color by Don Evans and Howard Schafer





RADAR ANTENNA

TWIN M-2 50-CAL MACHINE-GUN TURRET
(Fire 500 rpm about 7500 yards)

1150-HP TURBINE ENGINE

ARMOR-COVERED JET-ENGINE AIR INTAKE

RADAR OPERATOR

PILOT

HINGED ARMOR

20-MM M-3 CANNON MOUNTED ON PYLON SECURED TO FLOOR
(Fires up to 800 rpm about 6000 yards)

WEAPONS CONTROLLER
(Aims grenade launchers with periscope-like viewer)

40-MM XM-129 GRENADE LAUNCHER
(Fires high-velocity exploding projectiles automatically, 400 rpm about 2000 yards)

HINGED ARMOR
(Flips up for protection, flips down for visibility)

5.56-MM XM-134 MINIGUN
(One on each side.
Fires 4000 rpm about 1650 yards)

TAIL ASSEMBLY

MOVABLE RUDDERS
(Control vehicle by directing
blast from propeller)

DUAL-DRIVE
TRANSMISSION

3-BLADED 9-FT
PUSHER PROPELLER

7-FT CENTRIFUGAL
LIFT FAN

BUOYANCY TANKS

STORAGE AREA

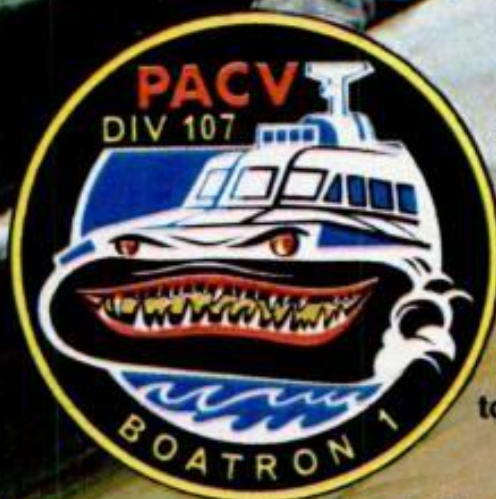
PUFF PORTS

FLEXIBLE
RUBBER SKIRT

PLENUM CHAMBER
(Arrows show direction
of air flow)

PUFF PORTS
(For yaw control)

FINGER SKIRTS
(Control air direction
under vehicle)



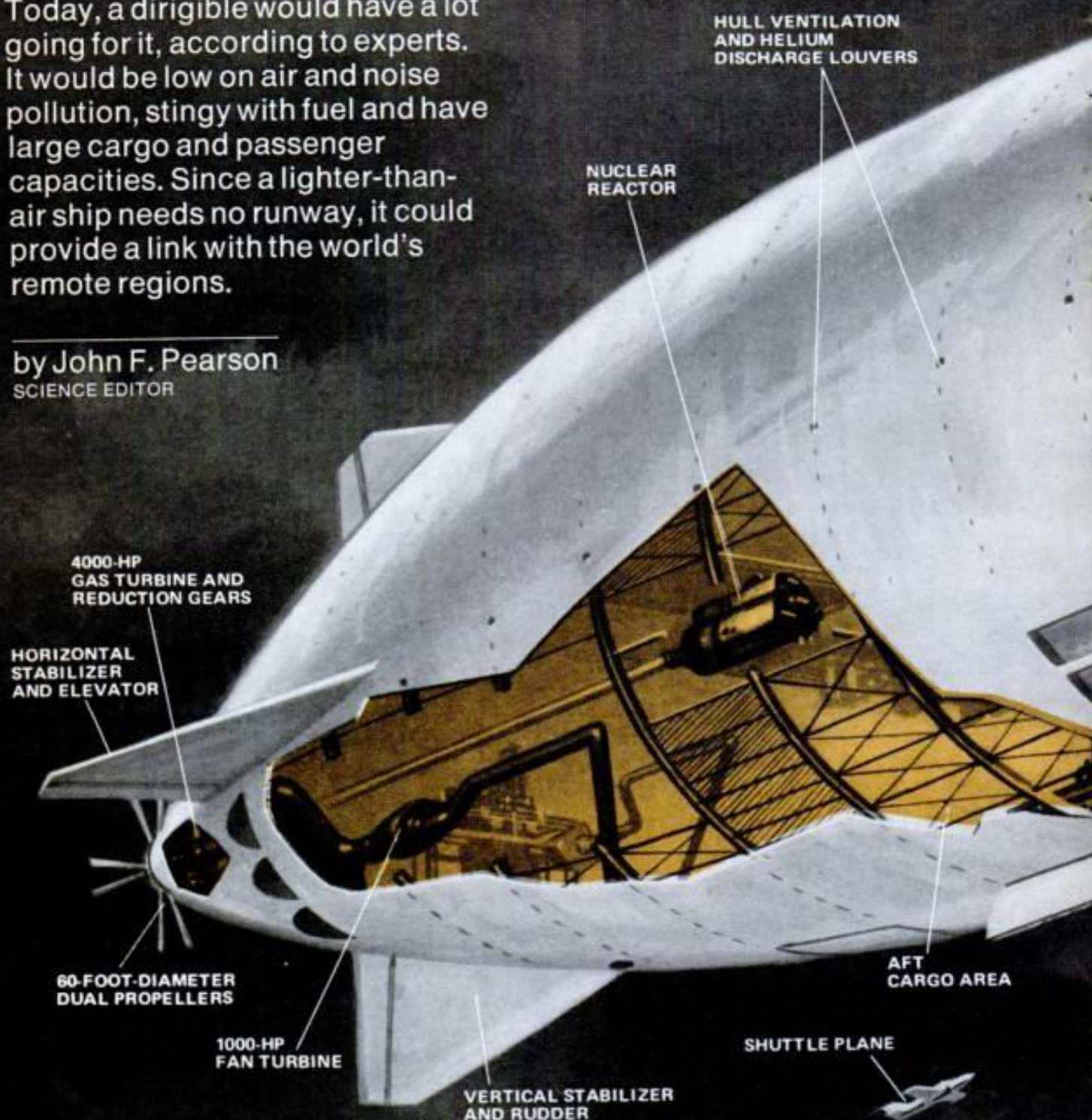
Floating fortress may look like this when it returns to combat in Vietnam. Planned improvements, shown in this PM version, include increased cabin size for larger crew, special armor plating for crew protection, larger engine for greater speed (up to 60 knots) and payload, finger skirts and puff ports for better control and, especially, devastating firepower to pursue and defeat the Vietcong.

Shoulder patch of first Navy ACV unit, Boatron 1, PACV (Patrol Air Cushion Vehicle.)

Don't sell the airship short

Today, a dirigible would have a lot going for it, according to experts. It would be low on air and noise pollution, stingy with fuel and have large cargo and passenger capacities. Since a lighter-than-air ship needs no runway, it could provide a link with the world's remote regions.

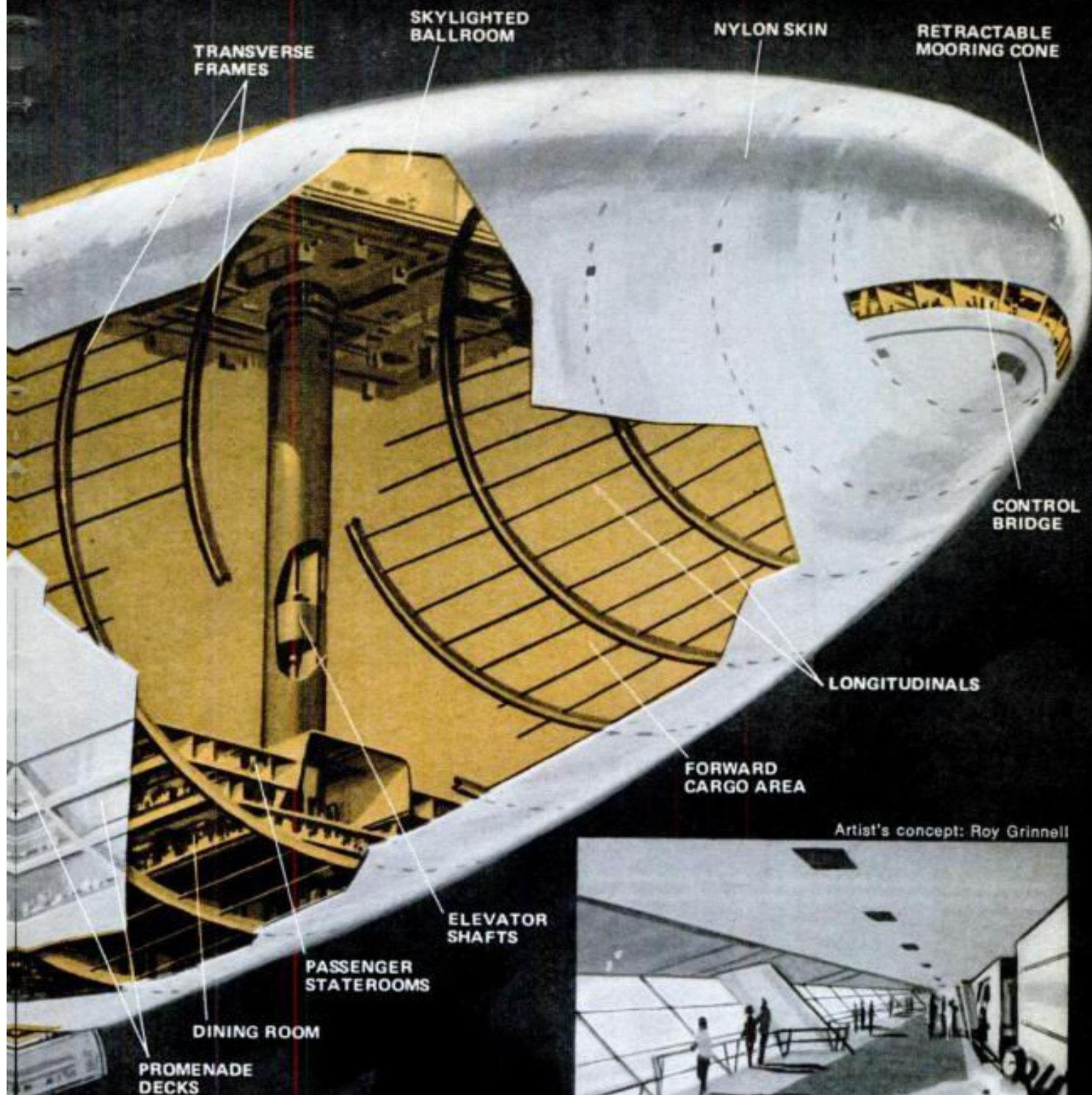
by John F. Pearson
SCIENCE EDITOR



Most Americans who remember the dirigible tend to think of it only as a symbol of a bygone day, as a form of transportation that relatively quickly lost the race against the faster, surer airplane. They recall the enthusiasm and spirit of adventure that marked many pioneering dirigible flights,

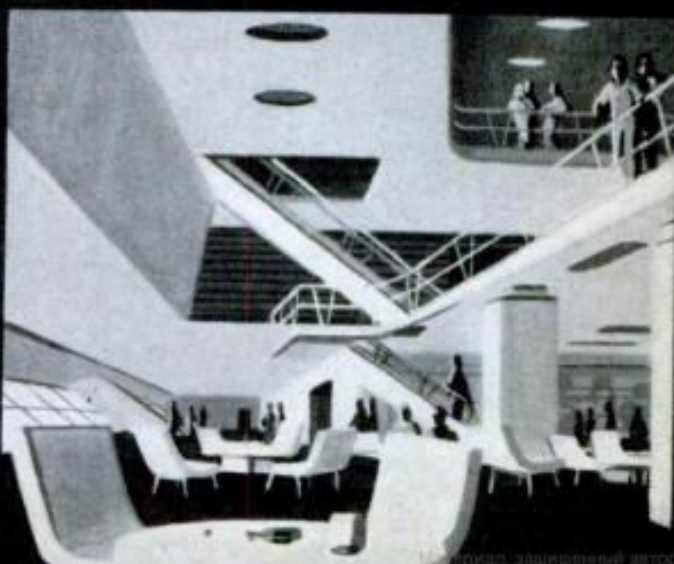
and they remember the tragedies, too. The newsreel image of a broken, flaming *Hindenburg* crashing at Lakehurst, N.J., in 1937 is hard to forget.

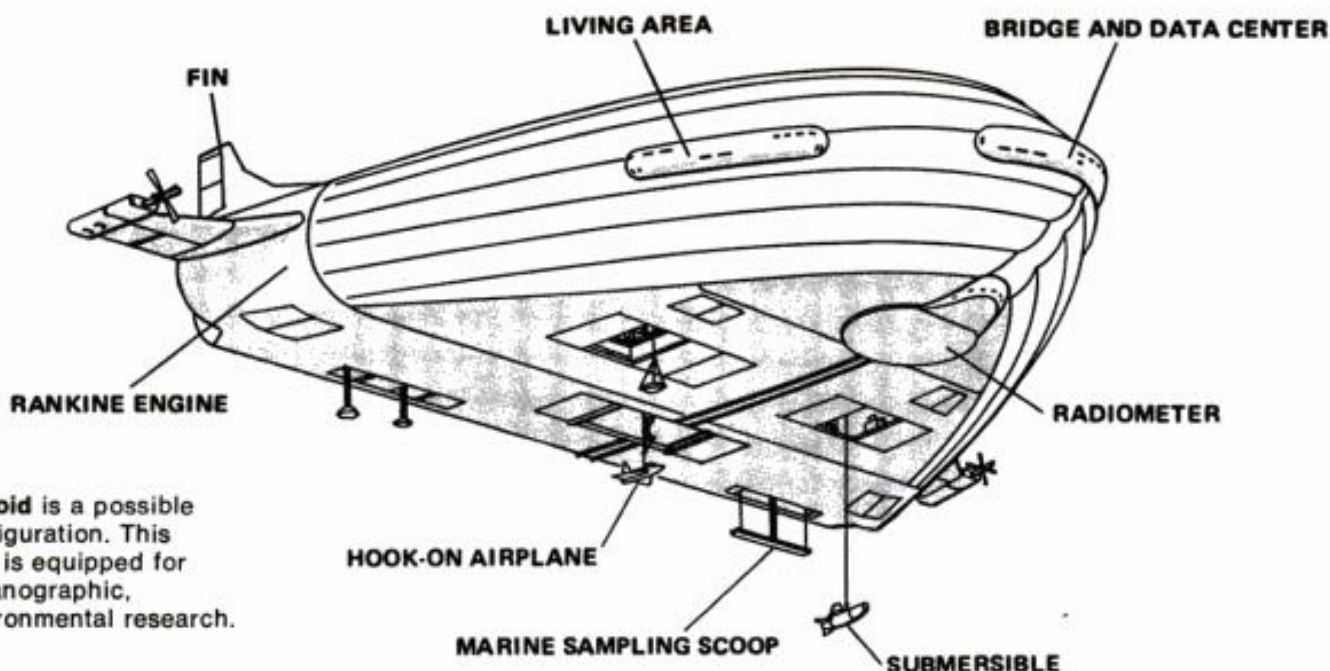
But there are men in this country who don't regard the airship as a gas-bag dinosaur. They view the rigid airship (as opposed



Artist's concept: Roy Grinnell

Nuclear airship, designed by Boston University engineers, would fly at about 100 mph and have a virtually unlimited range. In a passenger-cargo version, the 1000-foot ship would offer 400 passengers the comfort and luxury of an ocean liner—spacious lounges, staterooms, promenade decks. Instead of a five-day ocean voyage, however, a transatlantic trip by airship would take less than 40 hours. An all-cargo nuclear airship would excel at long-distance hauling with a payload capacity of some 300,000 pounds—equivalent to a shipment of 150 VW Beetles.





Deltoid is a possible configuration. This ship is equipped for oceanographic, environmental research.

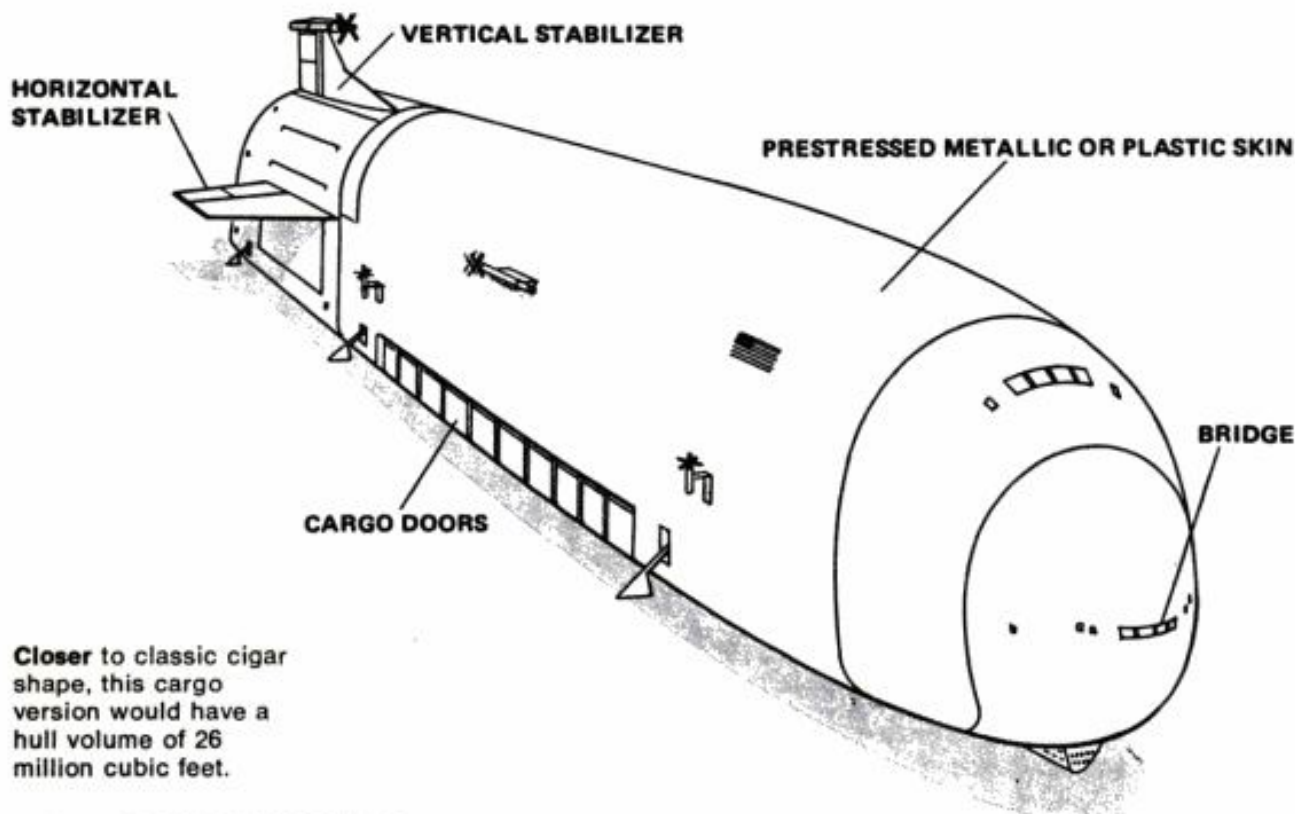
to the nonrigid blimp) as a craft with unrivaled capabilities. They point out that the "flying cigars" were produced by a technology now more than 40 years old. Today's technology, they say, could produce a far safer, more efficient dirigible.

These proponents of the updated airship are no idle dreamers but men of solid technical background. Francis Morse is an associate professor of aerospace engineering at Boston University; George J. O'Hara, a research engineer at the Naval Research Laboratory; Vladimar H. Pavlecka, a corporate technical director who helped design a famous Navy blimp, the ZMC-2; Kurt R.

Stehling, a propulsion specialist and technology advisor for Manned Undersea Activities, Office of Coastal Environment, and J. Gordon Vaeth, director of the Office of System Engineering, National Environmental Satellite Service.

In a number of recently published technical articles, they have made a good case for the rigid airship—a name they prefer to dirigible—as a passenger-cargo ship, all-cargo carrier, military or scientific research ship. A modern airship, they contend, would be ideal for nuclear propulsion, which would give it virtually unlimited range.

They describe a ship with an envelope or



Closer to classic cigar shape, this cargo version would have a hull volume of 26 million cubic feet.

Popular Mechanics

Today's technology makes it possible for
**DIRIGIBLES TO COME BACK
BIGGER THAN EVER**

Page 112

How experts make
used cars look like
new Page 104

VW-powered plane
you can build
from a kit
Page 78

The kayak
that makes
you a surfer
Page 61

How good is the Audi Fox?
What owners say Page 100

Clever disguises for
storage buildings
Page 146



nourished business, Amtrak has gone on a new equipment buying spree this year with Congressional help. At the top of its shopping list is the 120-mph turbine-powered train.

During October, 1973, Amtrak shipped from France two RTG turbotrains and put them into service between Chicago and St. Louis. The high-speed turbos ran up a 92-percent reliability record. Amtrak was impressed enough to

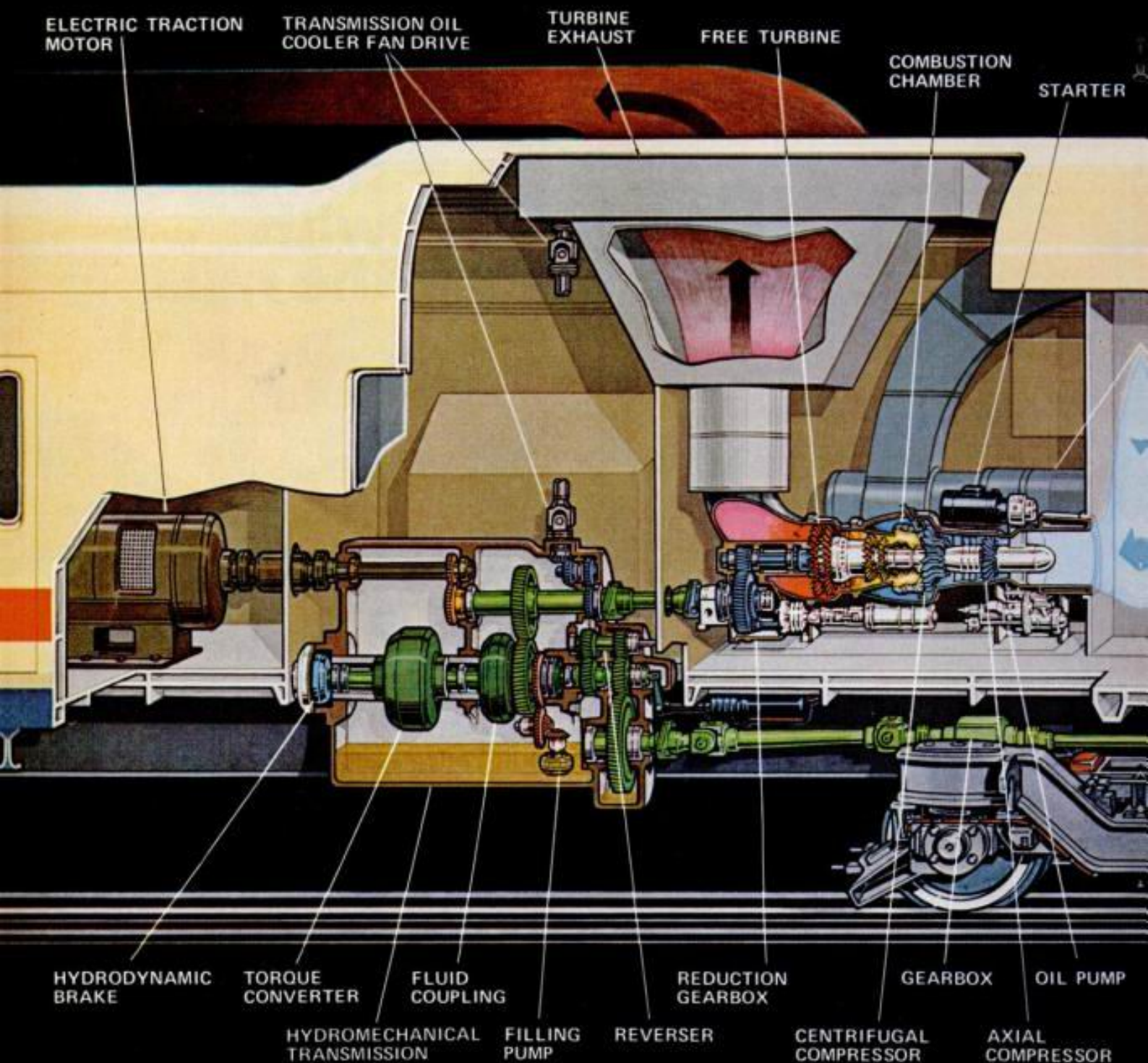
order four more from France and an additional seven, to be built in California, from Rohr Corp., the U.S. licensee.

Each five-car turbotrain set includes a power car at each end, so it's never necessary to turn the train around. There are two turbines in each power car: an 1140-hp two-shaft turbine that provides traction for the train through a massive, 7500-pound hydraulic transmission (see diagram), and

an auxiliary 430-hp single-shaft turbine for the train's internal electrical requirements, such as airconditioning in the cars. The big turbines at each end are used to accelerate the train, but one of them can be idled when the train reaches cruising speed. Only one of the auxiliary turbines is needed at a time, thus guaranteeing back-up power to the train.

The advantage of a turbine-powered train is that it has the

Power-car cutaway showing turbine, transmission and internal generator



Turbine details

TURBINE
EXHAUST

FREE TURBINE

TORCH IGNITER

COMBUSTION
CHAMBER

STARTER

AIR INTAKE

REDUCTION
GEARBOX

CENTRIFUGAL
COMPRESSOR

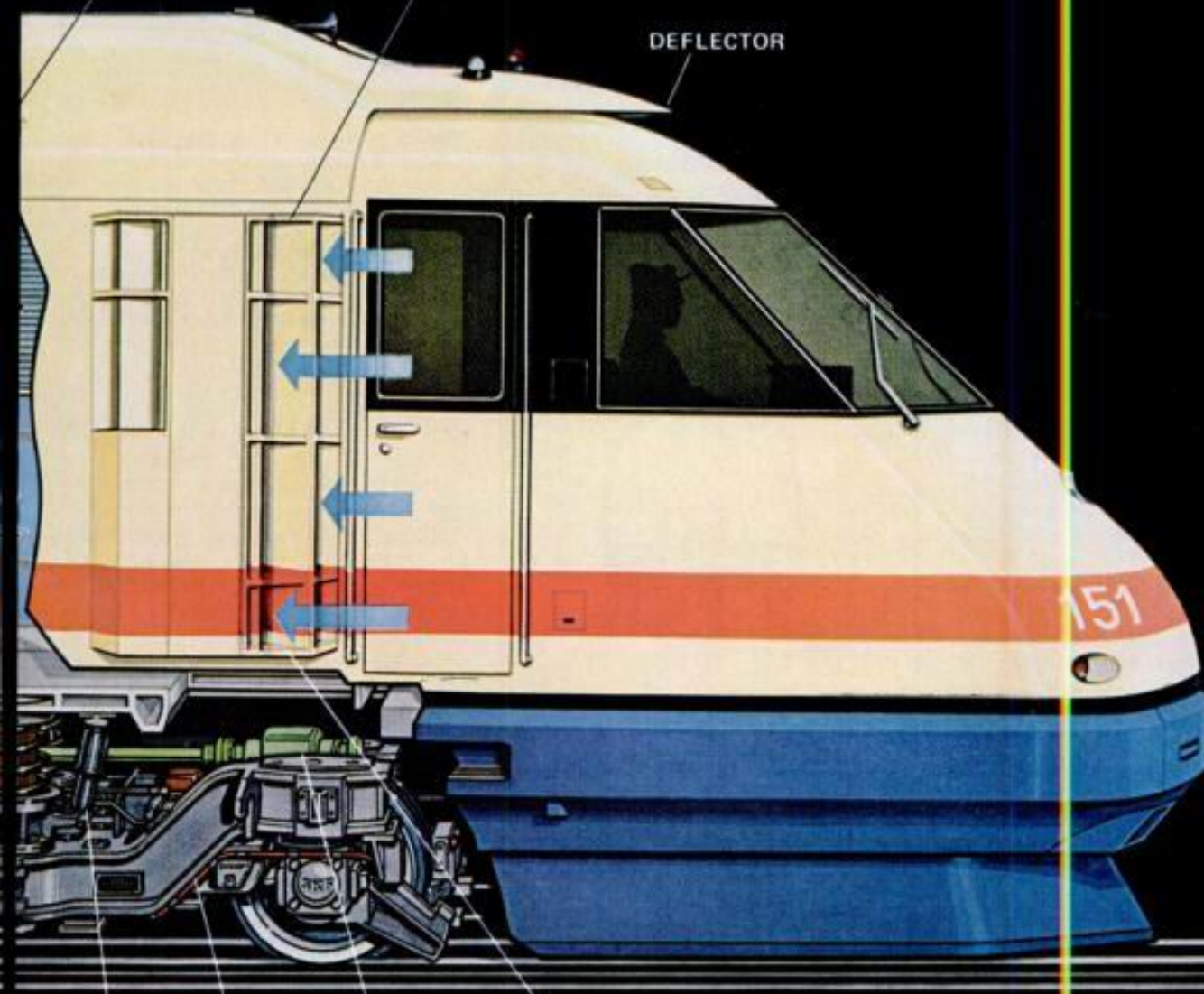
AXIAL
COMPRESSOR

OIL PUMP

AUXILIARY POWER
TURBINE/ALTERNATOR

TURBINE
AIR INTAKE

DEFLECTOR



BOGIE

TURBINE
AIR INTAKE

SHOCK ABSORBER

GEARBOX

They're hearing some discouraging words out where the deer and antelope play, at the federal railroad test center on the high plains of Pueblo, Colo.

There was a time, not long ago, when U.S. Department of Transportation (DOT) officials didn't think they could get funding for their \$80-million facility unless they called it the "High Speed Ground Transportation Center." Congressmen were excited at the time by researchers' predictions of 300-mph vehicles racing between cities, relieving clogged highways and backed-up airports of impatient travelers. The vehicles, levitated above a fixed guideway by magnetism or air cushions, would be able to "fly" under the power of electromagnetic induction motors.

But there was uneasiness beneath all the enthusiasm. People in the railroad business and the Federal Railroad Administration learned to refer politely to the high-speed systems as "advanced technologies" in public, but privately many people never got over calling them "Buck Rogers stuff." Nobody thought the research could pay off until the 1990s at the earliest.

In the past year, Congress too has grown impatient. Shying away from expensive test programs, it directed DOT to devote the taxpayers' dollars to more practical short-term improvement of the existing rail system. The rail traveler was to be gotten the 227 miles from New York to Washington in two hours, and not 40 minutes. DOT, ever sensitive to the winds of change, last December renamed its Pueblo test site the "Transportation Test Center."

Nowadays, when people talk about the passenger railroad of the future, they don't talk about the half-finished high-speed vehicles in Pueblo; they talk about technology that already exists. Train travel could become the preferred option for short

and medium distances here, as it has in other countries, using the same technology those other countries have used.

Europe is working on a 2000-mile system of high-speed lines to increase the railroads' hold on passenger travel there, and it is upgrading another 8700 miles. Already, West Germany alone has four times as many rail passengers as the United States, with less than a third of the population. The USSR's new "Russian Troika" makes the 400-mile run between Moscow and Leningrad in four hours. In Japan, the New Tokaido Line "Bullet" trains run every 15 minutes in each direction, averaging 102 mph over their 320-mile distance.

By contrast, America's showcase train, the New York-Washington Metroliner, sneaks up to 105 mph over one short section of track, and slow orders elsewhere cut its average to 75 mph. To travel 400 miles in the northeast corridor would take you over six hours.

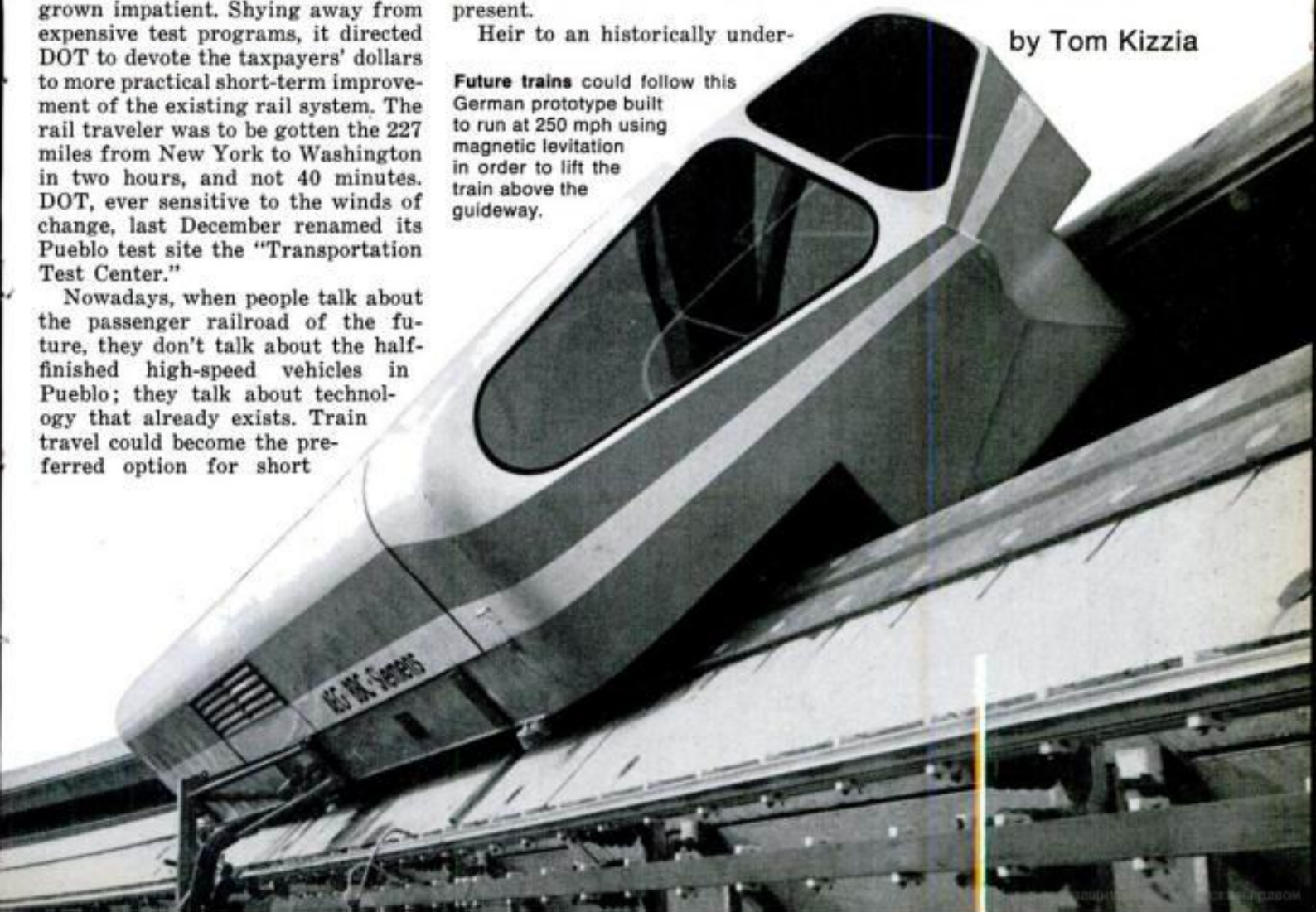
Amtrak, the quasi-public corporation created four years ago by Congress to take over the nation's dilapidated passenger trains, is busy these days trying to claw its way into the present.

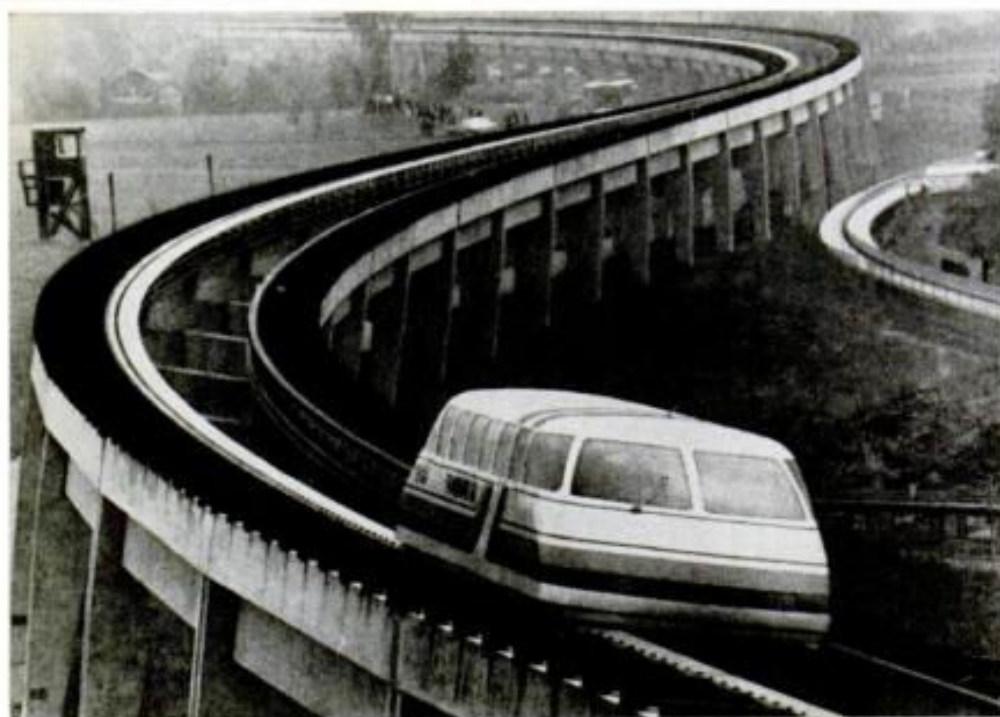
Heir to an historically under-

Future trains could follow this German prototype built to run at 250 mph using magnetic levitation in order to lift the train above the guideway.

New trains are reviving America's romance with the rails

by Tom Kizzia



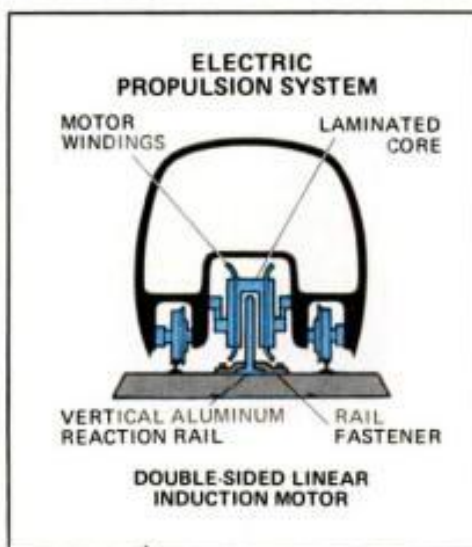


World's most advanced train (top right) is the British experimental Advanced Passenger Train especially designed to run 155 mph over unimproved track. LIM train (top left) may be America's answer to high-speed propulsion without rails. A German magnetic attraction vehicle (left) called Transrapid can go 120 mph with double speed planned. Tomorrow's freight may be transported by the multiwheeled Coaxial Train (above).

highest power-to-weight ratio available, making acceleration and braking easier. A complete five-car RTG train set weighs about 250 tons; a diesel-engine train, with four coaches to carry the same 300 passengers, weighs around 470 tons—almost twice as much. One disadvantage is the turbine's higher fuel consumption—but its lighter weight helps make up for that.

The seven Rohr-built turbos, first of which is due in April of next year, will be Americanized. For one thing, they will be seven inches higher and five inches wider. There will be more room for passengers, with capacity cut to 276 per train. Third-rail capability will be added, so that the train can switch over to electrical power when it enters New York—a sign that Amtrak is serious about its plan to use turbotrains between there and Boston.

Another change is being made partly at the request of the operators: a longer nose will be put on each end. The reasons aren't all aerodynamic. "Not only are there more grade crossings in America than in Europe," explains Fred Houser, railroad specialist for the Transportation Research Board in Washington, "but American



drivers seem to have considerably more confidence crossing them. The operators didn't like being right up front under those circumstances; this should keep the autos out of their laps."

Turbotrains may make a dent in a couple of heavily traveled corridors, but they are no panacea for the nation's rail ills. The RTG has been clocked in France at speeds as high as those achieved on the New Tokaido Line, over 130 mph—but in the Mid-

west it is held to 80-mph top speed by track conditions. The problem in the United States has been maintaining high speeds, not achieving them.

When Japan built the New Tokaido Line, it built a whole new railroad. Today in America a generation of locomotives is being introduced that takes into account less-than-perfect track structure. Originally designed for 150-mph runs, the famous Metroliner has been retrofitted to 130 mph maximum speed. Amtrak is now testing a 10,000-hp GE electric locomotive, capable of 120 mph for short acceleration. The GE locomotive would be used on electrified track in the northeast. Garrett and GE have built prototypes of a combination gas-turbine/electric locomotive.

In general, not much more than 120 mph is the speed railroad people mention when asked about the Train of the Future. The locomotives, whether turbine or electric, are available. There are even high-speed diesel trains being developed—in Britain, the HST (High Speed Train), in



Today's innovative freight cars, like this monstrous compact-car carrier, help keep railroads competitive with trucks.

Canada, the LRC (Light, Rapid, Comfortable). An HST prototype—which holds the diesel train speed record of 143 mph—is actually in service now between London and Bristol, and 27 more are expected to go into operation beginning next fall.

British Rail's Advanced Passenger Train (APT), now being tested, is probably just that—the most advanced train in the world. The idea is to build a train, with either gas turbine or electric motive power, that can reach high speeds on existing track. The secret is a new suspension system and a special car-tilting mechanism. Together they will permit the APT to speed around curves 50 percent faster than conventional trains.

Passenger trains would often be capable of going faster around curves if it weren't for passenger discomfort—there would be no danger of derailling, but passengers pitching into the aisles might justifiably jump to such a conclusion. As long as passenger trains share the track with slower-moving freight trains, some compromise must be reached in the banking

of the curves. Several years ago an Erie freight was forced to stop in the twisty Delaware Water Gap, and several cars on a sharply banked curve slid off. A derailment, standing still.

One way to keep passengers off the edge of their seats—and thereby speed up the train—is being experimented with in the APT and the Canadian LRC: a hydraulic banking mechanism which would automatically tilt the car more than the curve tilts the train, up to 9° extra in the case of the APT.

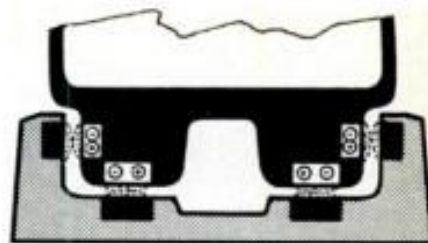
New cars are also being developed that will make riding America's rough railbed easier.

The first of 492 Metroliner-type coaches will be appearing late this summer in the United States—at long last, the first standard Amtrak coach. Until now Amtrak has had to make do with whatever cars it could find, and it scouted every railroad yard in the continent to scrape together its fleet of 2000.

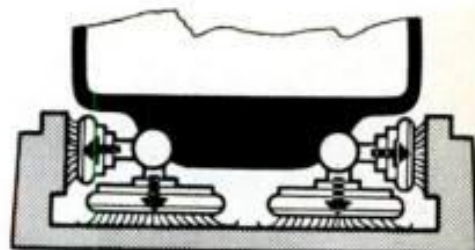
The new "Amcoach" will resemble the rounded Metroliner car, except that it will not carry its own electric motive power. Instead, it will be hauled by locomotive, thus allowing it to range outside the Northeast on other short-distance routes. Floor tracks in the new coaches will permit variable seat spacing.

Most of Amtrak's attention is going these days to the short-haul routes in corridors with high population density—routes where an improved system could give the airlines a run for their money—but it is not letting the long-haul passenger train go the way of the stagecoach, as some jet-setters have predicted. Amtrak has ordered 235 bilevel cars from Pullman-Standard, for delivery beginning in

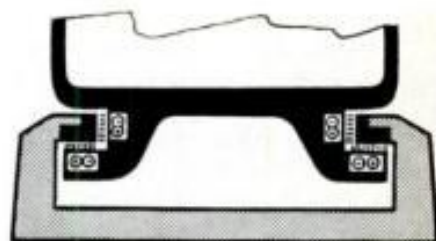
Guided Suspension Systems



**MAGNETIC
EDDY CURRENT REPULSION**



**AIR CUSHION
CHANNEL OR U GUIDEWAY**



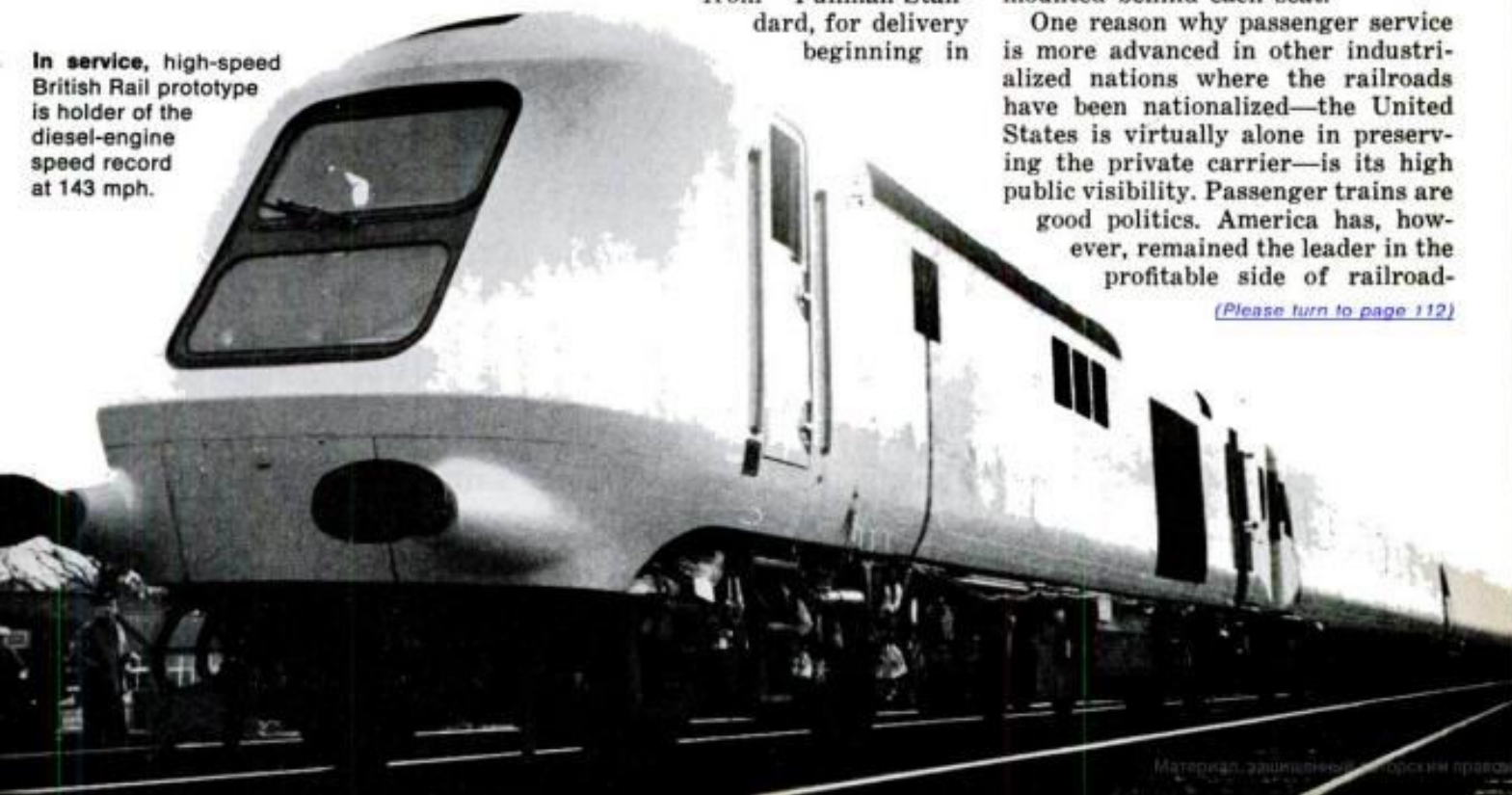
**MAGNETIC
FERRO-MAGNETIC ATTRACTION**

1977. The cars will provide coach seats, sleeping compartments, and dining facilities; diners upstairs should get the benefit of a much smoother ride. Seats will be spaced as far apart as first-class airline seats, with folding tray tables mounted behind each seat.

One reason why passenger service is more advanced in other industrialized nations where the railroads have been nationalized—the United States is virtually alone in preserving the private carrier—is its high public visibility. Passenger trains are good politics. America has, however, remained the leader in the profitable side of railroad-

(Please turn to page 112)

In service, high-speed British Rail prototype is holder of the diesel-engine speed record at 143 mph.



Popular Mechanics

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maybe
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**Build PM'S Back-Yard
Cookout Gazebo**

Page 160

**What Valiant Owners
Say About the Duster**

**Dan Gurney Answers
Your Questions About
Racing and Driving**

**A Submarine Icebreaker
For Arctic Oil?**

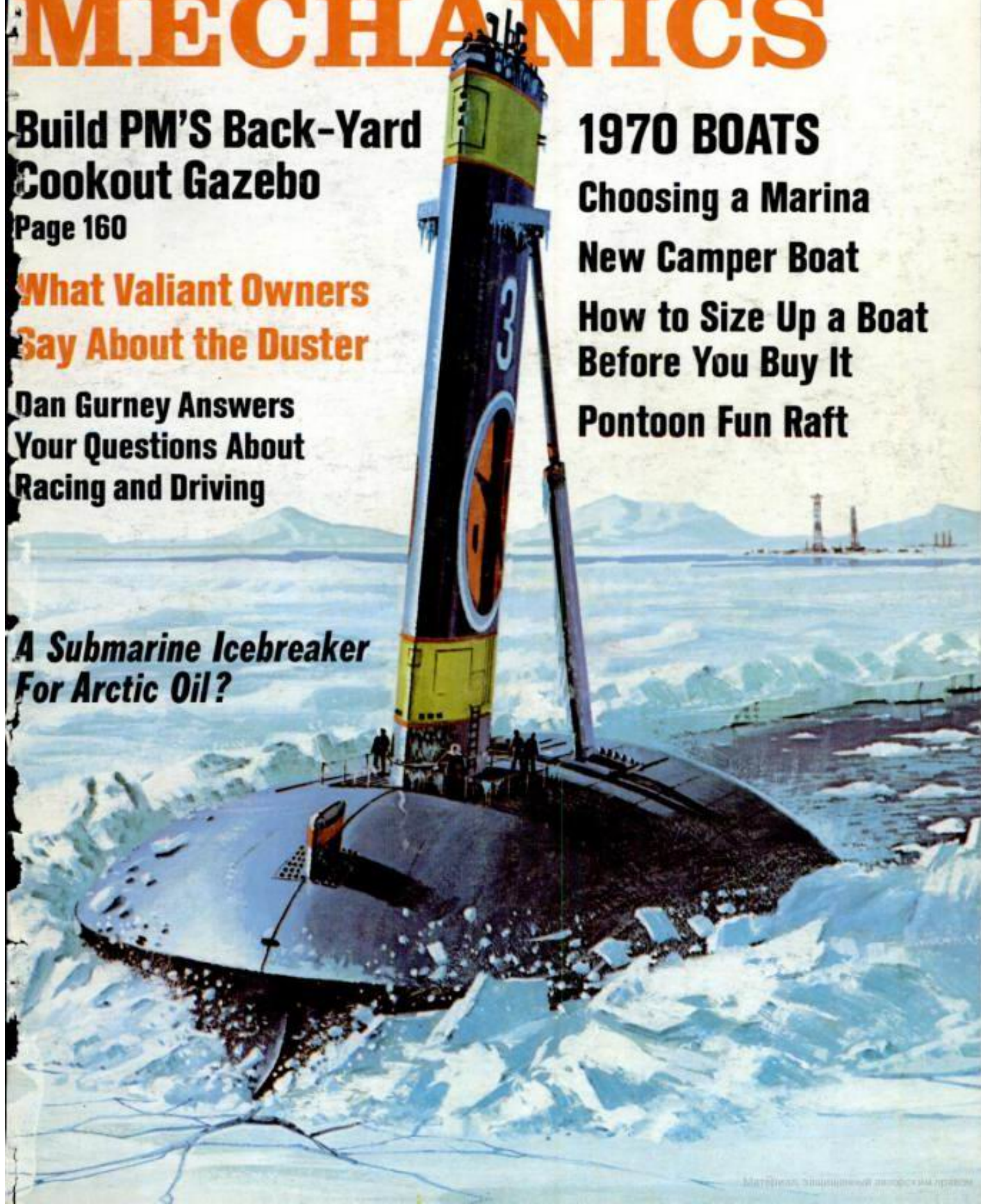
1970 BOATS

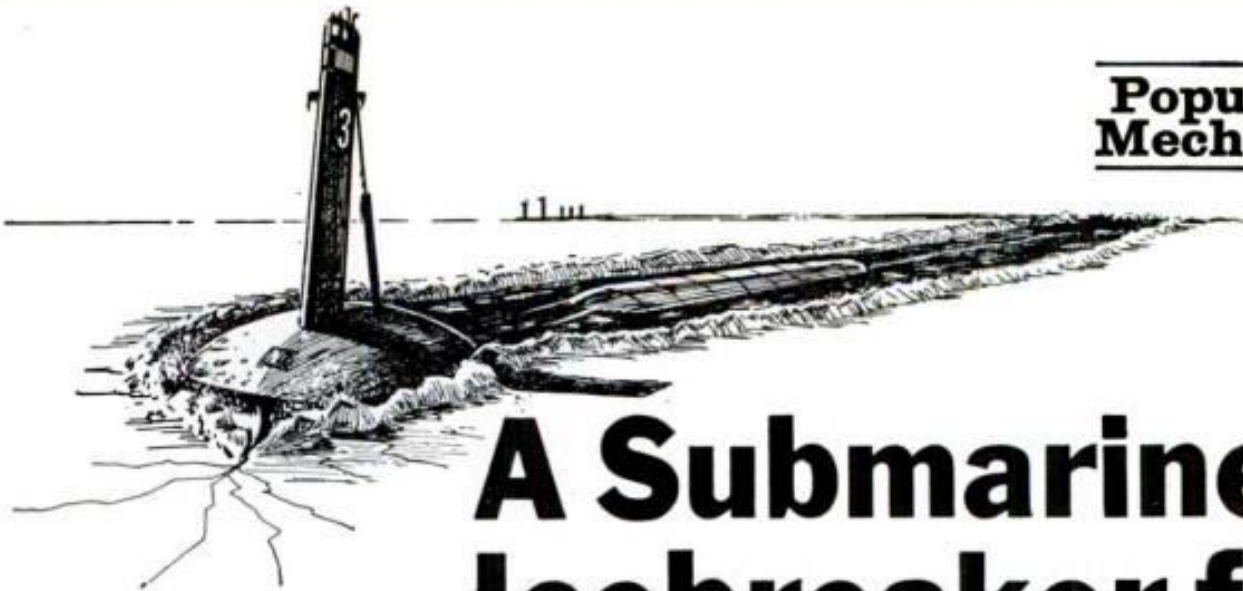
Choosing a Marina

New Camper Boat

**How to Size Up a Boat
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Pontoon Fun Raft





A Submarine Icebreaker for Arctic Oil?



POLAR EXPERT Bud Waite employed knowledge of arctic ice in designing novel ship



CO-INVENTOR Marcel Golay, research physicist, handled system's theoretical aspects

The strike on Alaska's North Slope, biggest in North America's history, poses a whale of a problem: how to ship the oil to the Lower 48. This exclusive report describes a unique system that could do the job.

By JOHN F. PEARSON, Science Editor

THE SUBLIKE SHIP BUCKS ARCTIC ICE five feet thick, its powerful undershot bow plowing the creaking, groaning ice upward and spilling it in huge pieces on either side of the hull. Headway is slow but steady as the ship travels east toward Melville Sound, bound for a port in lower Greenland.

The ship has a huge cylindrical barge under tow, which rides low in the water about 150 feet back. Its cargo: crude oil from Prudhoe Bay, Alaska.

"Ice island ahead," the radarman calls out in the ship's control room. "Range, 6000 yards."

The island is at least 10 miles square and could be as much as 100 feet thick. Except for 12 feet or so, most of that thickness is below surface. The skipper considers his options and decides against going around the island. That would take too much time. "Prepare to dive," he commands.

The conning tower, which had been halfway up, is retracted to its full-down position. Then the ship, still headed directly for the island, quickly sinks below the surface of the two-mile deep water, pulling the barge after it like a huge harpooned whale...

This is a description of a voyage that has yet to happen. So far it's a reality only in the minds of the engineer and the scientist who conceived this submarine-icebreaker-barge system of oil transport in ice-choked waters. (The system is described on page 87.) The inventors bring an

(Text continues on page 88)

85

Waite-Golay System for Transporting Oil from Alaska's North Slope

CONTROL HOUSE

DOCK

PUMP LINES

QUARTER BARGE

HALF BARGE

BARGE

ENGINE ROOM

MOTOR

CARGO TANKS

PASSAGEWAY

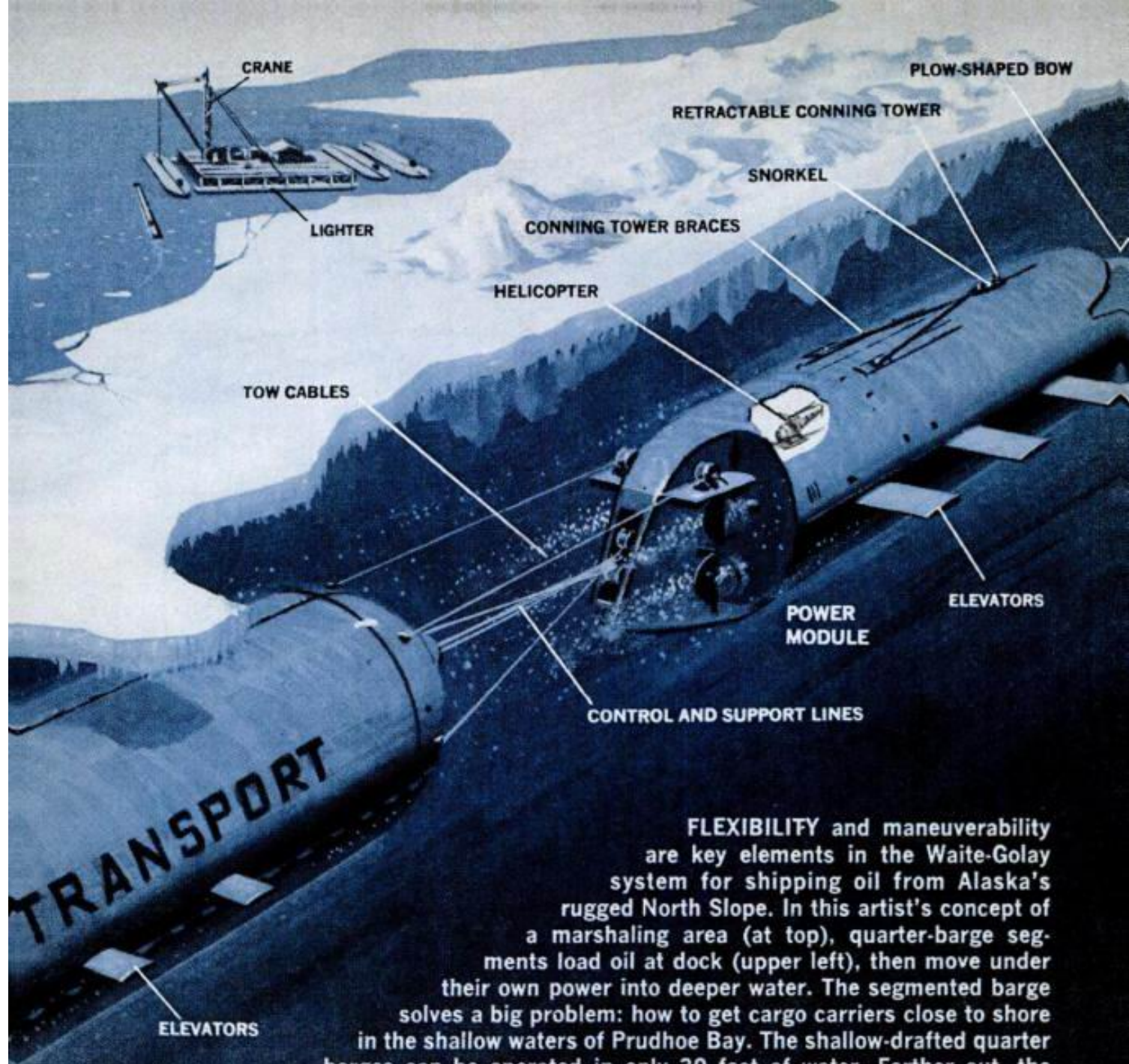
NACELLE

CREW'S QUARTERS

NACELLE BALANCING GEARS

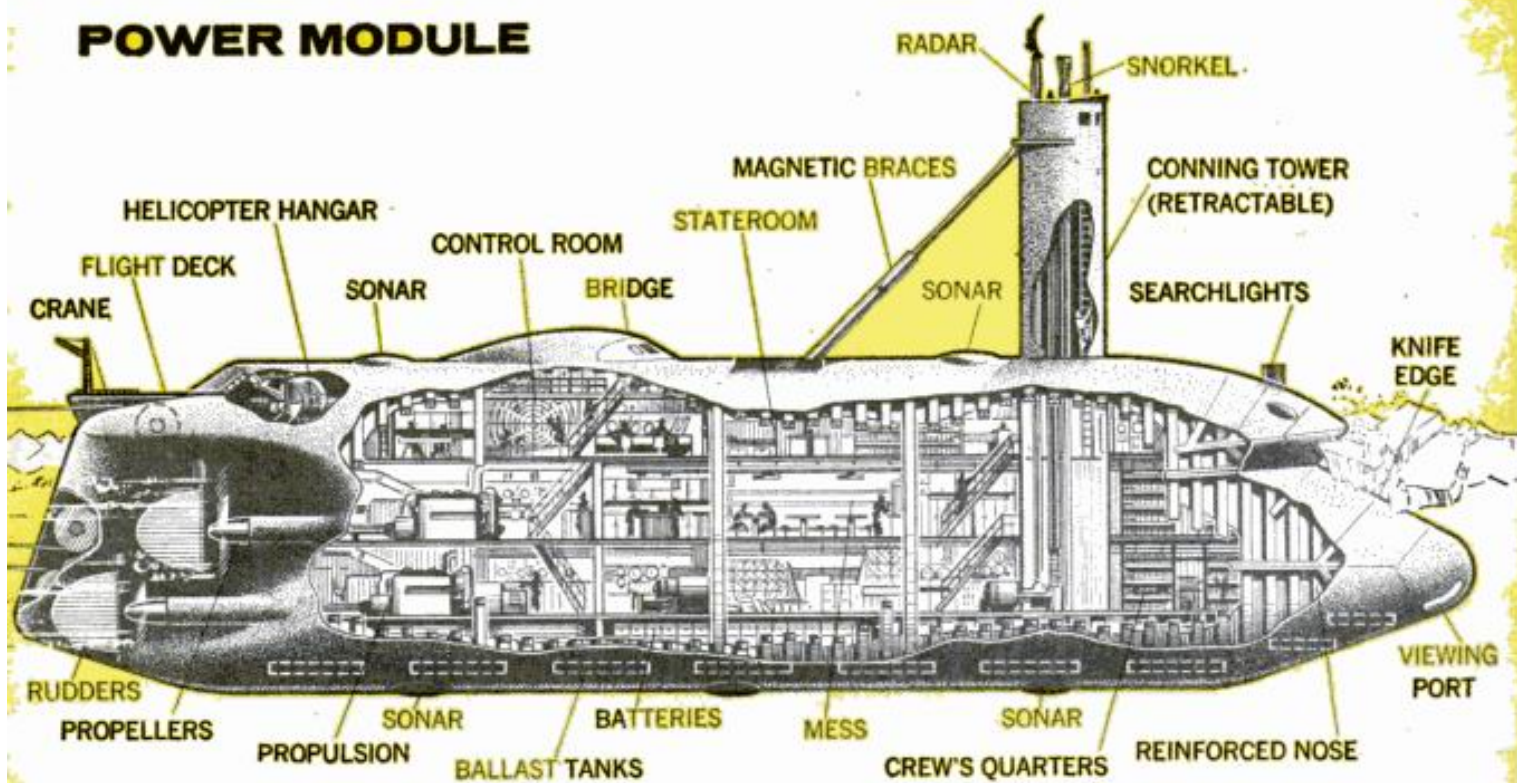
BATTERY COMPARTMENT

Art Concept by Ed Valigursky



FLEXIBILITY and maneuverability are key elements in the Waite-Golay system for shipping oil from Alaska's rugged North Slope. In this artist's concept of a marshaling area (at top), quarter-barge segments load oil at dock (upper left), then move under their own power into deeper water. The segmented barge solves a big problem: how to get cargo carriers close to shore in the shallow waters of Prudhoe Bay. The shallow-drafted quarter barges can be operated in only 30 feet of water. Farther out, the quarter segments are joined into half barges. At the lighter, a crane drops cubical control houses into position to provide the half barges with full maneuverability. Finally, the fully loaded half segments are mated to create cylindrical barges 900 feet long and 90 feet in diameter. Total cargo: 160,000 tons of crude. The 350-foot power module, which functions like a locomotive, takes the barge under tow in relatively deep water. In addition to tow cables, the two vessels are joined by control and other support lines. Thus, when under way the barge is controlled from the power module's command station. The vessels travel on the surface or under the water, as conditions dictate. In a heavy sea, for example, they'd make better time underwater, using the power module's snorkel and main engines. They run submerged under thick ice, with the power module's conning tower fully retracted. But for ice a foot or less thick, the conning tower would be up, its forward knife edge slicing through the ice. For ice up to five feet thick, the two vessels would normally be on the surface, with the power module's plow-shaped bow heaving the ice upward and out to clear a channel. In tougher situations, the barge could move under its own power, following the power module as it rammed its way forward. Leaving the North Slope, the module and barge are likely to head for a port in southern Greenland, where the cargo can be transferred to standard tankers for the final leg of the trip to an East Coast refinery. Then, the power module, towing a barge filled with water ballast, returns to Prudhoe Bay. The shuttle system is designed for year-round service.

POWER MODULE



unusual combination of field experience and expertise to the task.

The engineer is Amory H. (Bud) Waite Jr., a retired Army Signal Corps electronics and radio expert who may know more about polar ice than any man on earth. His specialty is devising systems and equipment for measuring ice with radio waves.

Over a span of 35 years, Waite traveled more than 100,000 miles on ice-breakers and took part in 12 Arctic and 11 Antarctic expeditions. In 1934 he was one of three men to rescue Adm. Richard E. Byrd, who had become incapacitated while manning a lonely outpost south of Little America. Bud Waite was given a Congressional Medal for that heroic deed.

Co-inventor Dr. Marcel J.E. Golay is also a veteran of the Signal Corps. He is a physicist who can lay claim to many scientific achievements, among them the development of sound-ranging systems during World War II and the invention of the Golay infrared detector. Dr. Golay now serves as a senior scientist at Perkin-Elmer Corp., a leading maker of scientific instruments.

Though Bud Waite had done considerable thinking about the problems of moving ships in polar regions, it was

not until the oil strike on Alaska's North Slope, announced early in 1968, that he and his partner got down to serious work.

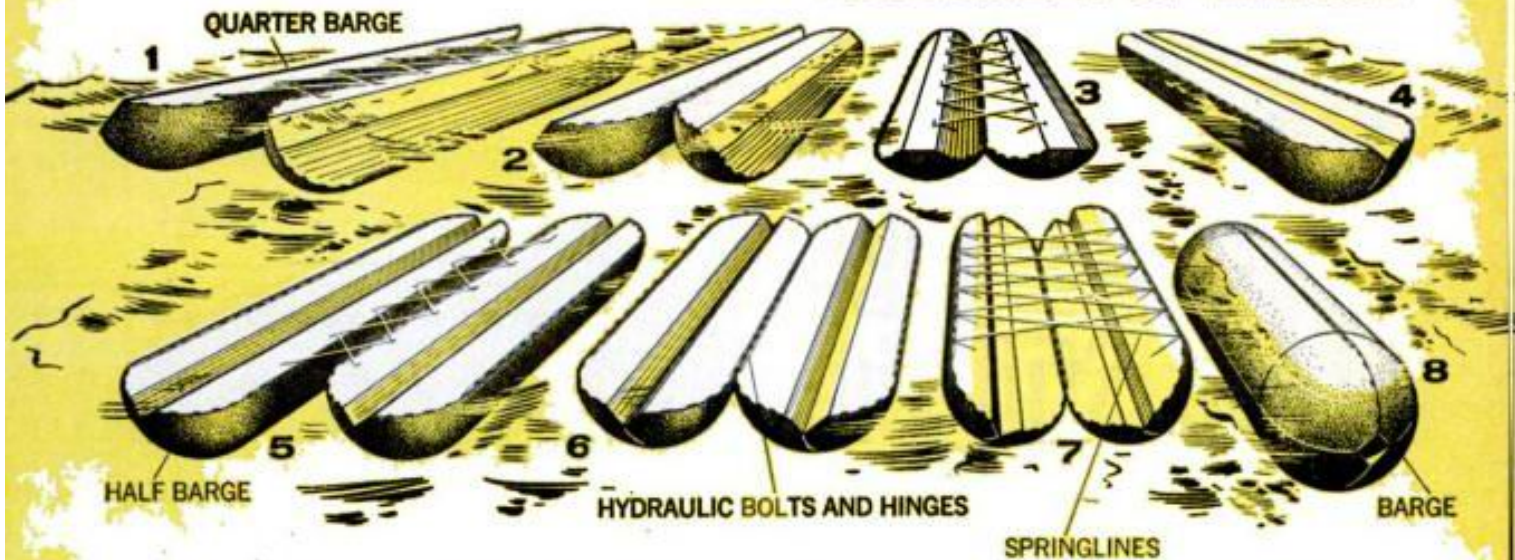
This biggest oil discovery in the history of North America also represents the toughest challenge ever faced by our oil industry. The big hurdle: how to ship oil from the frozen North to refineries and markets in the lower 48 states. Oil men are particularly interested in developing an economical method for transporting the oil to the populous East Coast.

So far, two standard approaches and one slightly offbeat method have come to light:

- **Pipeline.** According to present plans, an 800-mile pipeline will be built from Prudhoe Bay to a port on Alaska's southern coast. A tough, \$1 billion job—and it won't help to get Arctic oil to the East Coast.

- **Surface icebreaker-tanker.** It's unlikely that big-capacity ships like the *SS Manhattan*, which made headlines last fall by becoming the first commercial vessel to conquer the Northwest Passage, will ever be able to get through on a year-round basis, a requirement if their operation is to be commercially successful. A ship like

ASSEMBLY OF BARGE



BALANCING TANKS IN BARGE SEGMENTS are used to change attitude of segments during assembly operation. Segments are pulled close with springlines, then joined by means of a hydraulic bolting mechanism

TECHNICAL ART CONCEPT BY FRED WOLFF

the *Manhattan*, says Waite, has too broad a bow and too little power to smash through thick ice, and is too long to maneuver among big ice cakes. For the most part, the stuff the *Manhattan* went through was soft summer ice, perhaps little more than a foot thick in places. "Slush" is Waite's word for it. Even so, the big ship got stuck at times, requiring help from an icebreaker, and sustained a hole in her hull.

"What will a big tanker like that do with winter ice of five to seven feet?" Waite asks. "Not to mention ice that may run up to 15 feet thick in places and cakes that might be 40 feet thick."

- *Nuclear submarine tanker.* The General Dynamics Corp. proposes to build nuclear subs capable of carrying 170,000 tons of oil. They would operate only below the surface and would not be icebreakers.

Waite and Golay spell out the advantages of their system in this way:

- They say that the cost of the nuclear sub's powerplant would be twice that of their conventionally powered ship. Dr. Golay estimates that shipping costs would be about one-third higher for the nuclear vessel.

- The barge concept provides for a huge cargo capacity without cutting

down on maneuverability. In ice that would stop a big surface tanker, the power module could punch out a channel in which the barge could follow under its own power (enough to make a few knots). Or the two ships could dive under the ice.

- The water off Alaska's north coast tends to be shallow out to a distance of 40 to 50 miles. The barge can be loaded relatively close to shore because it breaks into four quarters, which individually can operate in shallow water. The surface tanker and the nuclear sub require deeper water for loading.

- The Waite-Golay system has a built-in growth factor. The power module would be capable of towing very large barges—over 1000 feet long—which would make for a very economical operation. Dr. Golay estimates these long jobs could carry 240,000 tons of oil.

- If required, the power module could be adapted to nuclear power.

All in all, the submarine-icebreaker system is an imaginative piece of work. Whether it wins the North Slope transportation sweepstakes remains to be seen. Waite and Golay have made patent applications and, at this writing, are "talking" to several oil companies involved in the Arctic venture. ★★

of them with guns, rockets and missiles. It will fly fast and it will fly long.

In short, the F-14 is an air-superiority fighter, designed to clear the skies of anything that might threaten the fleet.

Of course, the Navy quickly adds, with the boys from the budget bureau breathing down their necks, the F-14 will also be able to strap on extra "garbage," like bombs, for air-to-ground missions, thus proving its versatility. Are we back to the F-111?

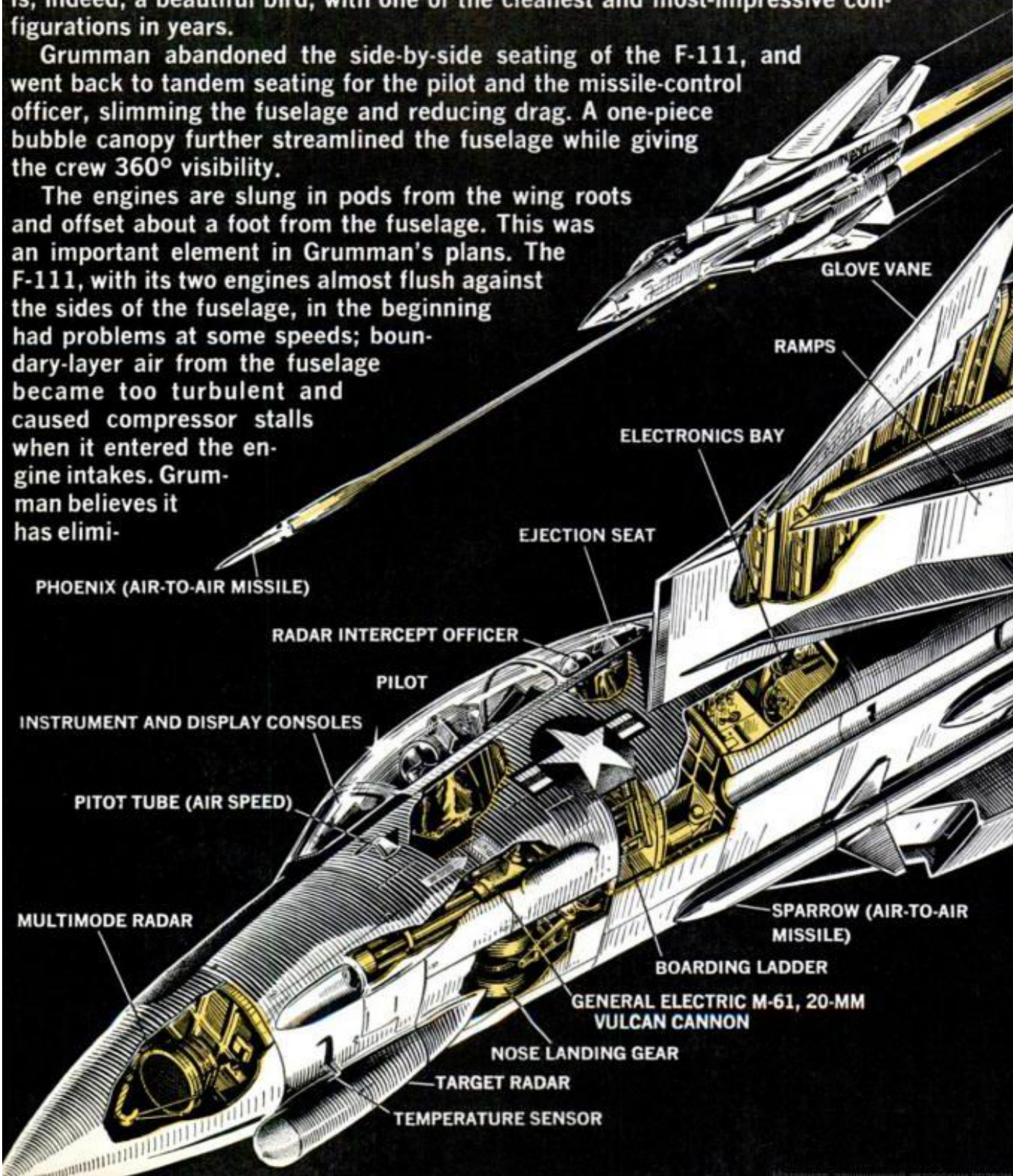
Not quite. The F-111 is a superior air-to-ground attack aircraft and, as such, probably should have been designated the A-111. But, in the air, the F-14 could probably run rings around it.

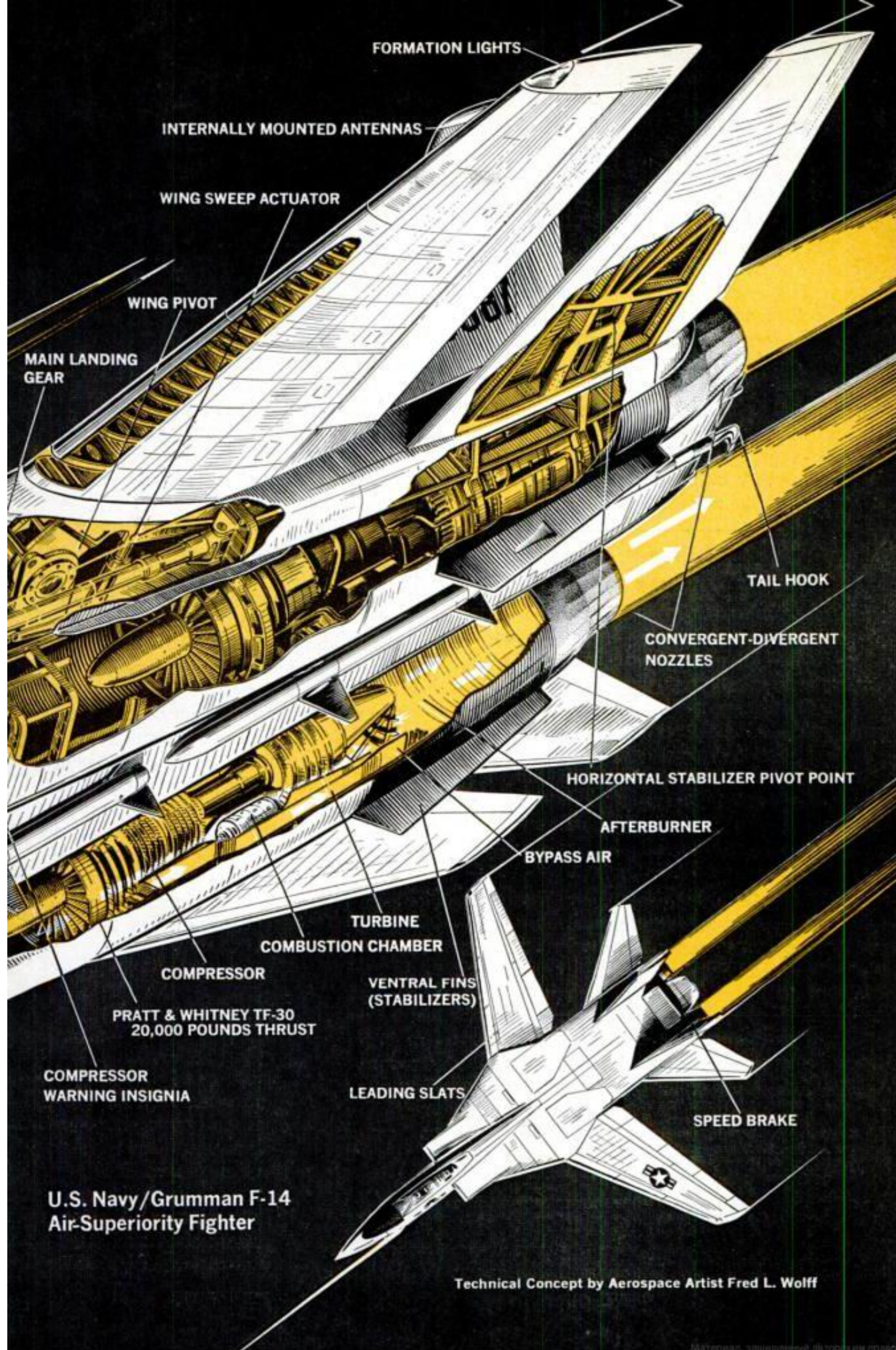
What, then, will the F-14 have that the Navy wants, and that the F-111 lacked?

In any study of this newest of aircraft, you almost have to start with its looks. It is, indeed, a beautiful bird, with one of the cleanest and most-impressive configurations in years.

Grumman abandoned the side-by-side seating of the F-111, and went back to tandem seating for the pilot and the missile-control officer, slimming the fuselage and reducing drag. A one-piece bubble canopy further streamlined the fuselage while giving the crew 360° visibility.

The engines are slung in pods from the wing roots and offset about a foot from the fuselage. This was an important element in Grumman's plans. The F-111, with its two engines almost flush against the sides of the fuselage, in the beginning had problems at some speeds; boundary-layer air from the fuselage became too turbulent and caused compressor stalls when it entered the engine intakes. Grumman believes it has elimi-





FORMATION LIGHTS

INTERNALLY MOUNTED ANTENNAS

WING SWEEP ACTUATOR

WING PIVOT

MAIN LANDING GEAR

TAIL HOOK

CONVERGENT-DIVERGENT NOZZLES

HORIZONTAL STABILIZER PIVOT POINT

AFTERBURNER

BYPASS AIR

TURBINE
COMBUSTION CHAMBER

COMPRESSOR

PRATT & WHITNEY TF-30
20,000 POUNDS THRUST

COMPRESSOR
WARNING INSIGNIA

VENTRAL FINS
(STABILIZERS)

LEADING SLATS

SPEED BRAKE

U.S. Navy/Grumman F-14
Air-Superiority Fighter

Technical Concept by Aerospace Artist Fred L. Wolff

AIR SPEED: 375 KNOTS

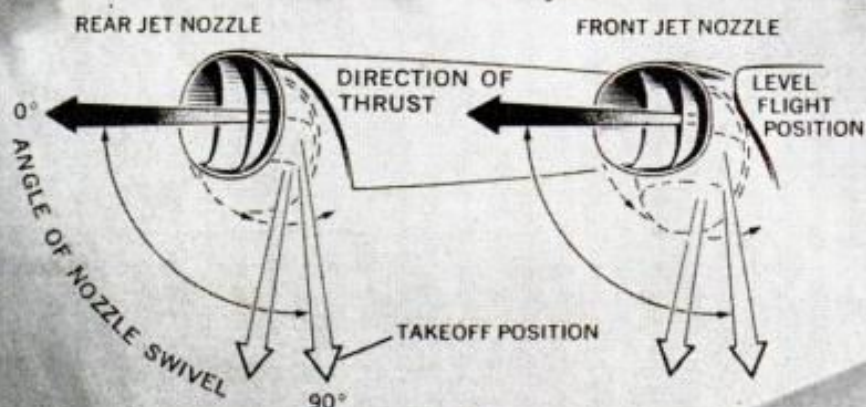
NOZZLES AT 0°

The Plane

AIR SPEED: 120 KNOTS

NOZZLES ROTATED TO 98°

Nozzle Vector System



NOZZLES RESET TO 65°

AIR SPEED: 80 KNOTS

ROLL-REACTION NOZZLE

OUTRIGGER LANDING GEAR

HF AERIAL

VHF AERIAL

SECURITY FORCES

Art Concept by Fred L. Wolff and Roy Grinnell

R. Grinnell

The British-built Harrier can take off or land on a site no larger than a tennis court; it has all the advantages of a chopper and none of the drawbacks

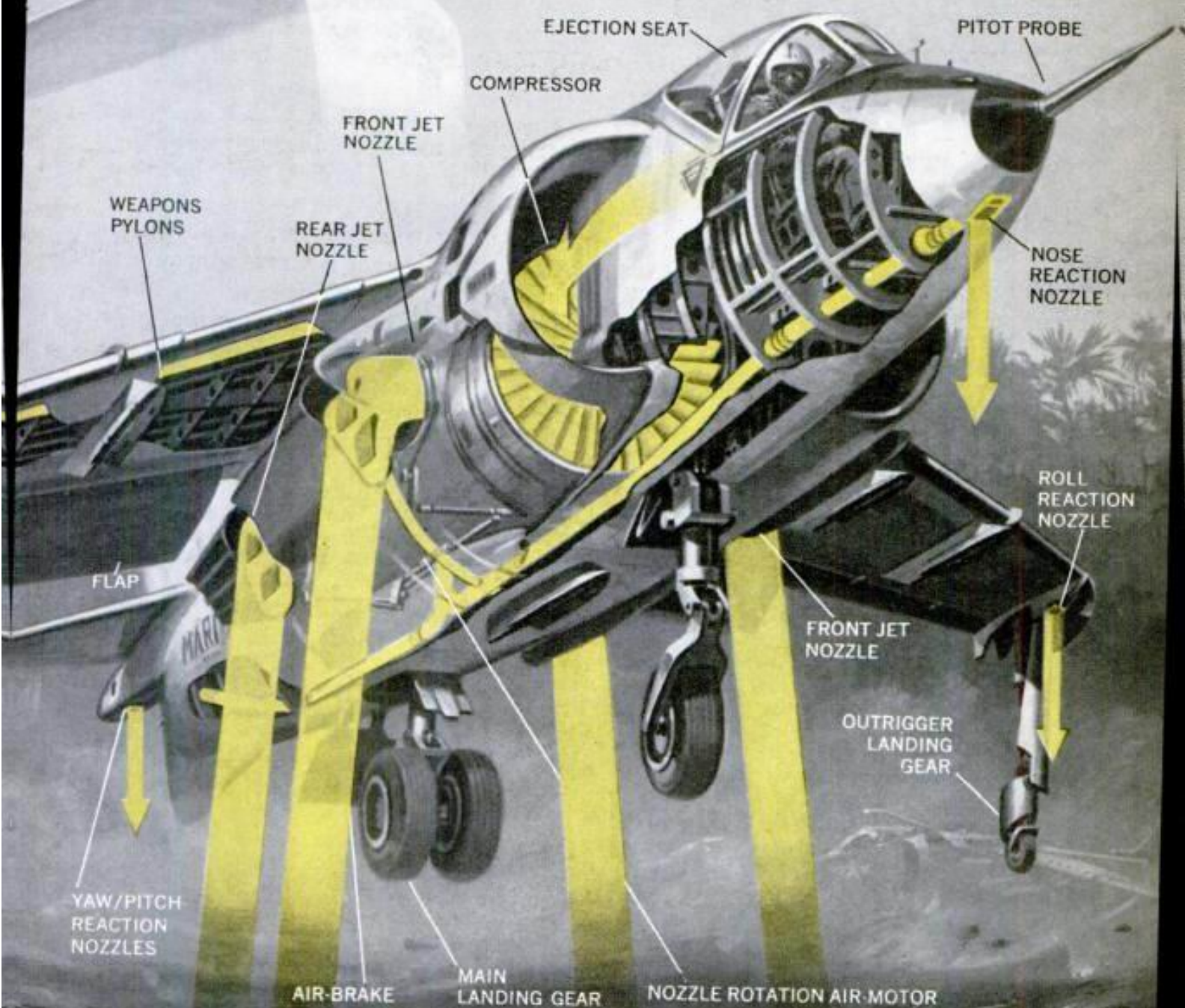
That Makes Airfields Obsolete

By KEVIN BROWN

A HIGH-SPEED PLANE that can take off and land vertically without need for long runways—or even an airfield—has long eluded the best efforts of the aircraft industry.

American attempts to develop STOL (Short Takeoff or Landing) and VTOL (Vertical Takeoff or Landing) planes have been spectacularly unsuccessful.

Meanwhile, the British have been working quietly on their version of a VTOL, which, after several test models,



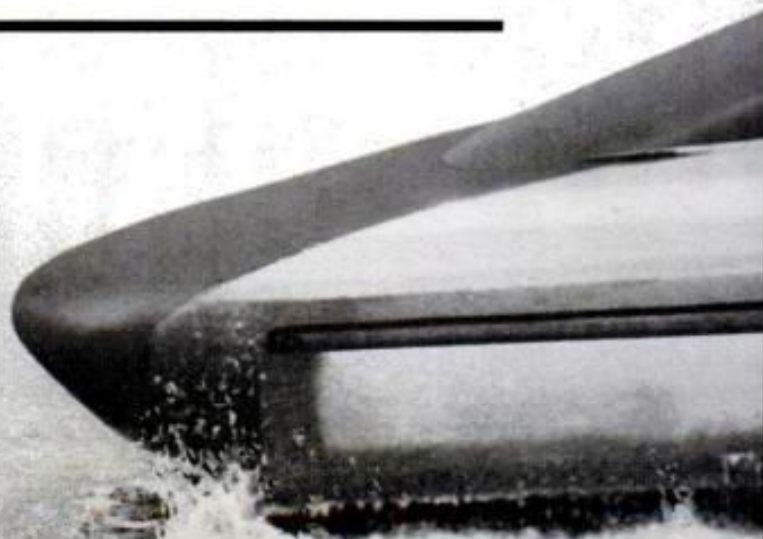


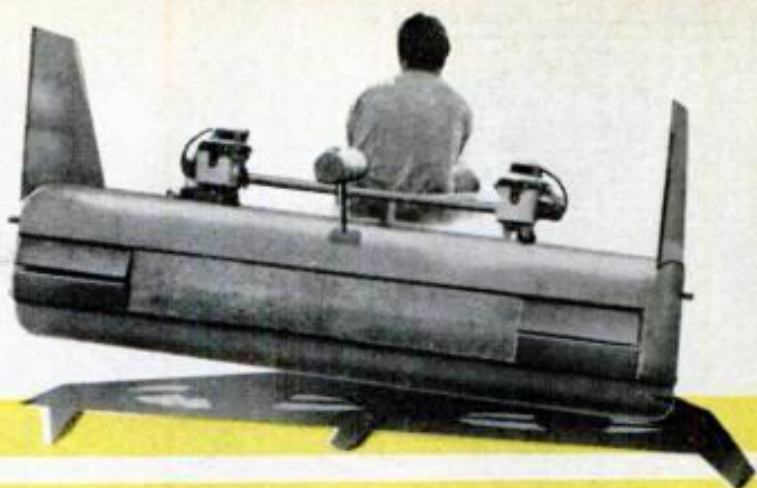
BUILD THE *Yellow Jacket* FOR \$400.

Here's a hot little air-cushion vehicle that hovers at 5 inches and goes up to 50 mph.

By ROBERT Q. RILEY

PLANS AVAILABLE. A set of complete plans and instructions for building the Yellow Jacket can be obtained by writing Popular Mechanics Magazine, 224 W. 57th St., New York, N. Y. 10019. Enclose \$15. Specify Yellow Jacket plans.





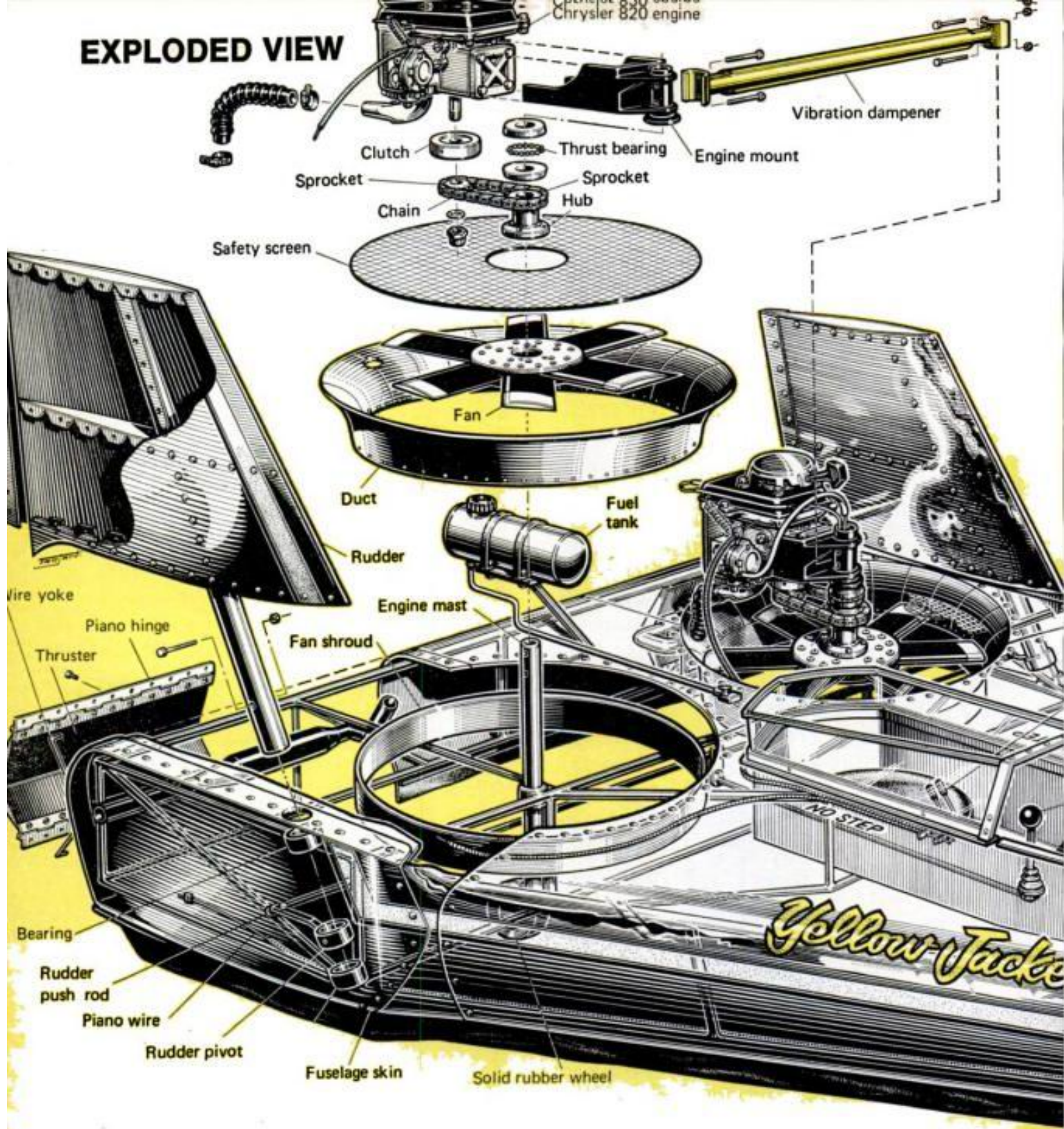
FLYING THE YELLOW JACKET is quite an experience. You first start the two go-kart engines using the rope starters. Then, after letting the engines warm up a bit, you climb aboard. At about one-third throttle the skirt suddenly inflates like a balloon, and the craft pops up about 5 in. and sits on the edge of the skirt. At about half to three-quarter throttle you are airborne. Once contact with the ground is lost, you are instantly aware of the complete absence of friction. Simply by leaning one way or the other, you can make the Yellow Jacket spin around in a circle, move backwards, sideways, or perform a combination of all these. At low speeds, you use the pedal-operated thrusters for steering; the rudders don't become effective until you reach 20 to 25 mph. At that speed the craft is very stable and the only way to change direction is with the rudders. Over water the craft is no speed demon, but take her over open, flat land and she will really sail.

Yellow Jacket is a result of the engineering know-how of Eugene Gluhareff, former helicopter designer and project engineer at the Sikorsky Aircraft Co.

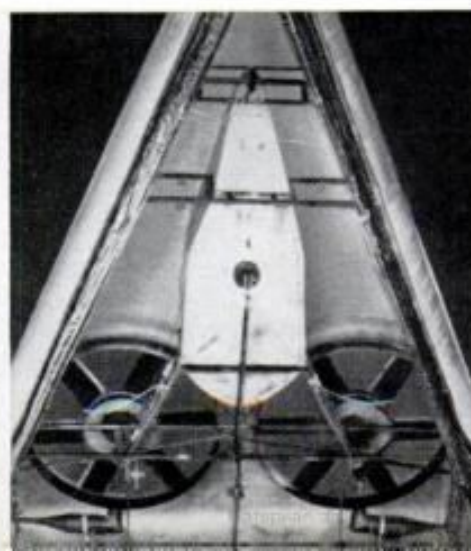
"The failing with most small air-cushion vehicles," Gluhareff says, "is that the air is not used efficiently. Many times the builder will employ a standard



EXPLODED VIEW



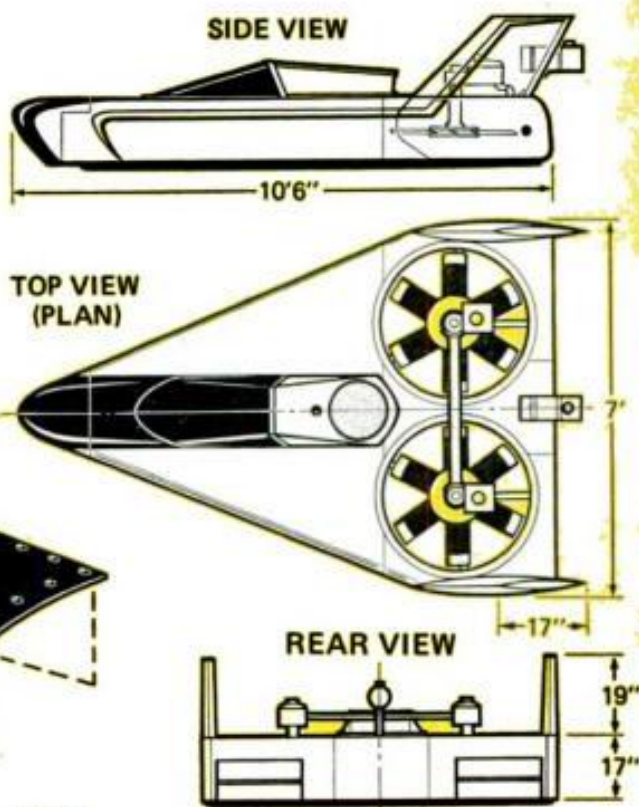
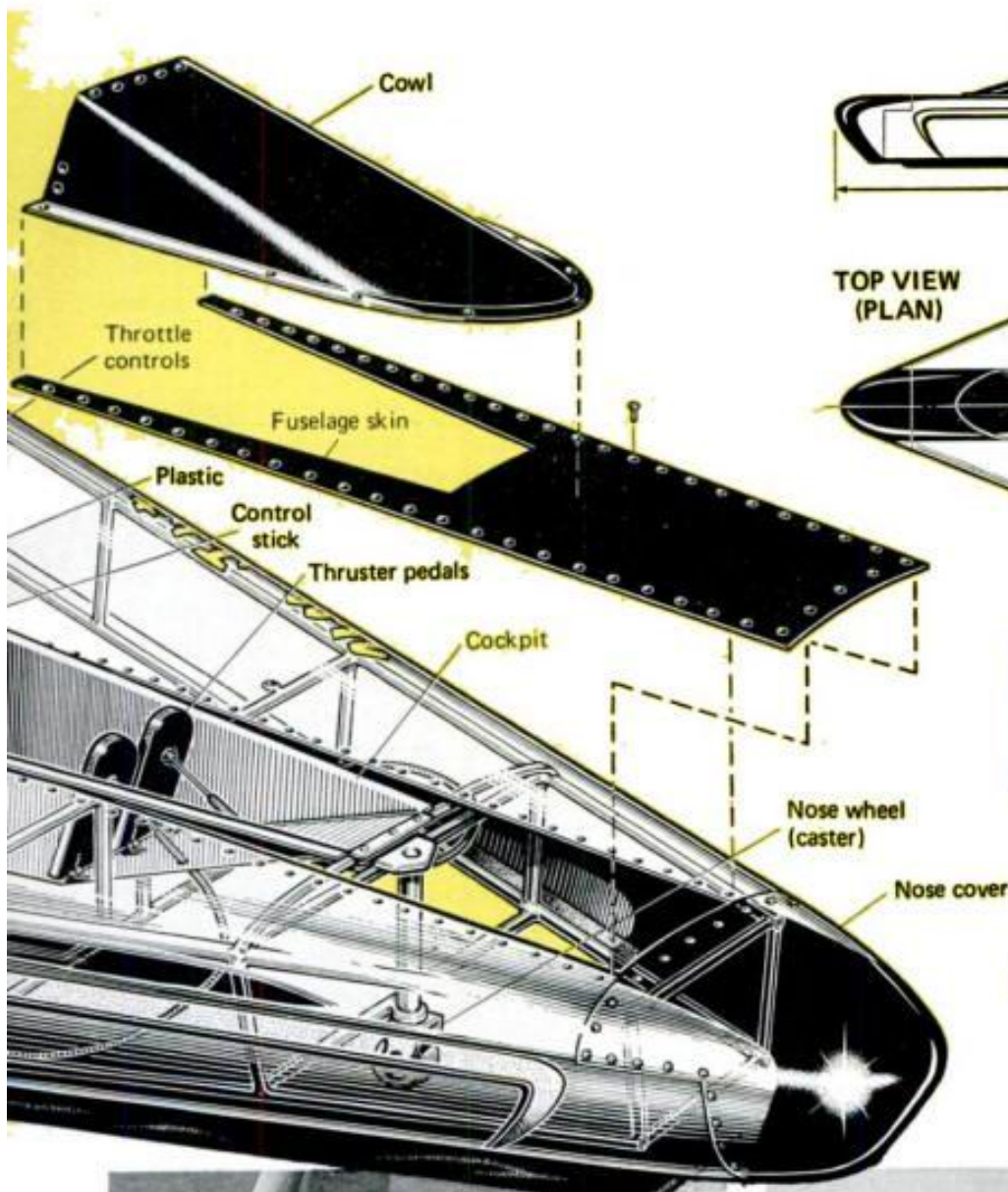
BUILDING the Yellow Jacket is a lot easier than it appears, and the craft is pure fun to operate. The plans offered (see page 126) include a pattern for making the prop. If you lack a router or the patience, you can have a prop maker turn it out. For speediest reply when ordering plans, address your envelope to PM's Reader Service Bureau 128



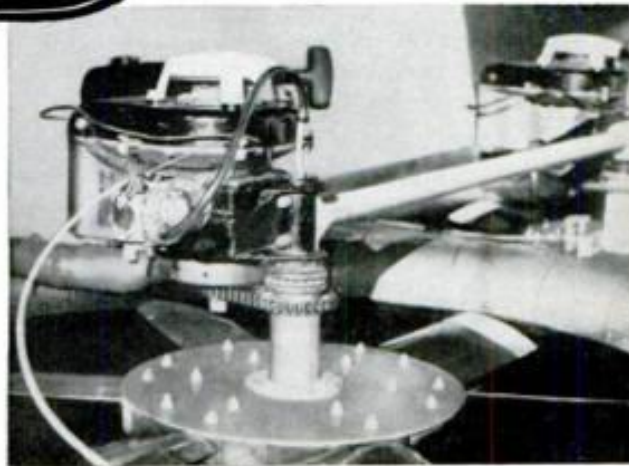
propeller is great until you put it next to the ground. But this creates a strong back-pressure and the propeller loses most of its efficiency." So he started the Yellow Jacket from scratch, designing two very efficient compression fans around the powerful Chrysler 820 go-kart engine. For more lift, he cambered the fan blades like airplane wings. At a 3600-rpm operating speed, the blades act as miniature wings

moving at over 300 mph. "Finally," he continued, "I designed the fuselage in the shape of a flying wing, which creates lift as it moves through the air." (Ed. note: This accounts for increased altitude as Yellow Jacket gains speed.)

To build the Yellow Jacket, Eugene used readily available materials throughout. The frame is, principally, 7/8-in. dia. (Please turn to page 182)



Technical Art Created by Peter Trojan,
Based on Drawings by Dave Carey



Ideas From the World's Biggest Inventors Show

POPULAR MECHANICS

MAR. 1971
50 CENTS

Polaroid
Self-
Focusing
Camera



Build the Yellow Jacket

Page 126

**Pinto vs. Vega: Coast-to-Coast
Comparison Run!** Page 76

**Dan Gurney Talks About His
Biggest Thrills and Auto Racing's Future**

Trouble-Shooting Small Gas Engines • Weekend Projects

BOATS

What's New for '71 • Matching Hull to Horsepower
Just-for-Fun 'Water Toys' • Center-Console Boats
The Newest Jets • How to Repair Fiberglass Hulls



'A-Wax'...

It Protects the Surface From Six Miles Up!

You spell it AWACS—an eight-engined 707 with enough radar, radio and computers to boss a whole battle.

By MERLE E. DOWD

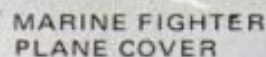
THOUGH IT SOUNDS like something you might polish your car with, it's designed to polish off an enemy. AWACS (pronounced a-wax) stands for Airborne Warning and Control System. It's a flying nerve center—a big jet crammed with the most complex package of communications, display and computer gear ever assembled in a single plane. And it's a full-scale radar station that can operate at 30,000 feet.

AWACS is the Air Force's newest defense system. In its tactical role, it will provide a commanding officer with the best "view" any general ever had of a battle.

From its sky-high position, AWACS monitors the progressing action (see illustration on the following two pages). Radios crackle; an artillery man relays a call through AWACS for an air strike against a stubborn mortar position. Radar picks up a flight of enemy attack fighters as they streak through the hills 100 miles away. As

radar and computers vector the fighters' position, a signal scrambles an interceptor squadron to surprise the attackers. An urgent radio message calls for an air-evac helicopter to pick up wounded. Infrared sensors locate enemy troops infiltrating along a supply route. An observer pinpoints the position and calls for fighter-bombers. Following a tip from an AWACS observer, fire-belching gunships attack a band of guerrillas waiting to ambush a convoy. Navy attack-bombers appear on an AWACS screen as they catapult from carriers off the coast and assemble for a low-level strike at coastal defenses.

Communications form the hub of AWACS activity. Radio, TV, infrared and other sensors, and the all-important radar flood displays and earphones with information as AWACS loiters above the battlefield. Radar blips constantly update map displays. Signalmen hunched over cathode tube (CRT) display consoles or seated with



MAIN SUPPLY ROAD
BLOCKED BY ENEMY AMBUSH

U-2 HIGH-ALTITUDE
RECONNAISSANCE PLANE

PUFF THE MAGIC DRAGON
SUPPORTING A BESIEGED
U.S. MARINE PATROL

TACTICAL INFANTRY PARACHUTE ASSAULT

ARMY HELICOPTER GUNSHIPS

AMPHIBIOUS
LANDING

ENEMY INTERCEPTORS

HELICOPTER,
INFANTRY
ASSAULT

ENEMY ROCKET BATTERY UNDER AIRCRAFT ASSAULT

ENEMY MECHANIZED ATTACK

FIGHTER GROUND-SUPPORT MISSION

headphones in front of maps relay messages back and forth among walkie-talkie-equipped ground troops, field commanders, attack aircraft in the area, and naval gun batteries offshore.

Great gobs of data pour in. The officers aboard AWACS know more about developments on the ground and in the air than any commanders ever knew before—and while it is all happening.



SUB RECON MISSION

B-52
BOMBING
MISSION

U.S. SHIPS MOVE
TO NEW POSITION

NAVY FIGHTER PLANES TAKE
OFF ON INTERDICTION MISSION

TROOPSHIP WITH
MEN FOR ASSAULT

AMPHIBIOUS
LANDING

FIGHTER GROUND-SUPPORT MISSION

AIR-CUSHION
VEHICLES

ARMY INFANTRY PATROL
REQUIRES ARTILLERY SUPPORT

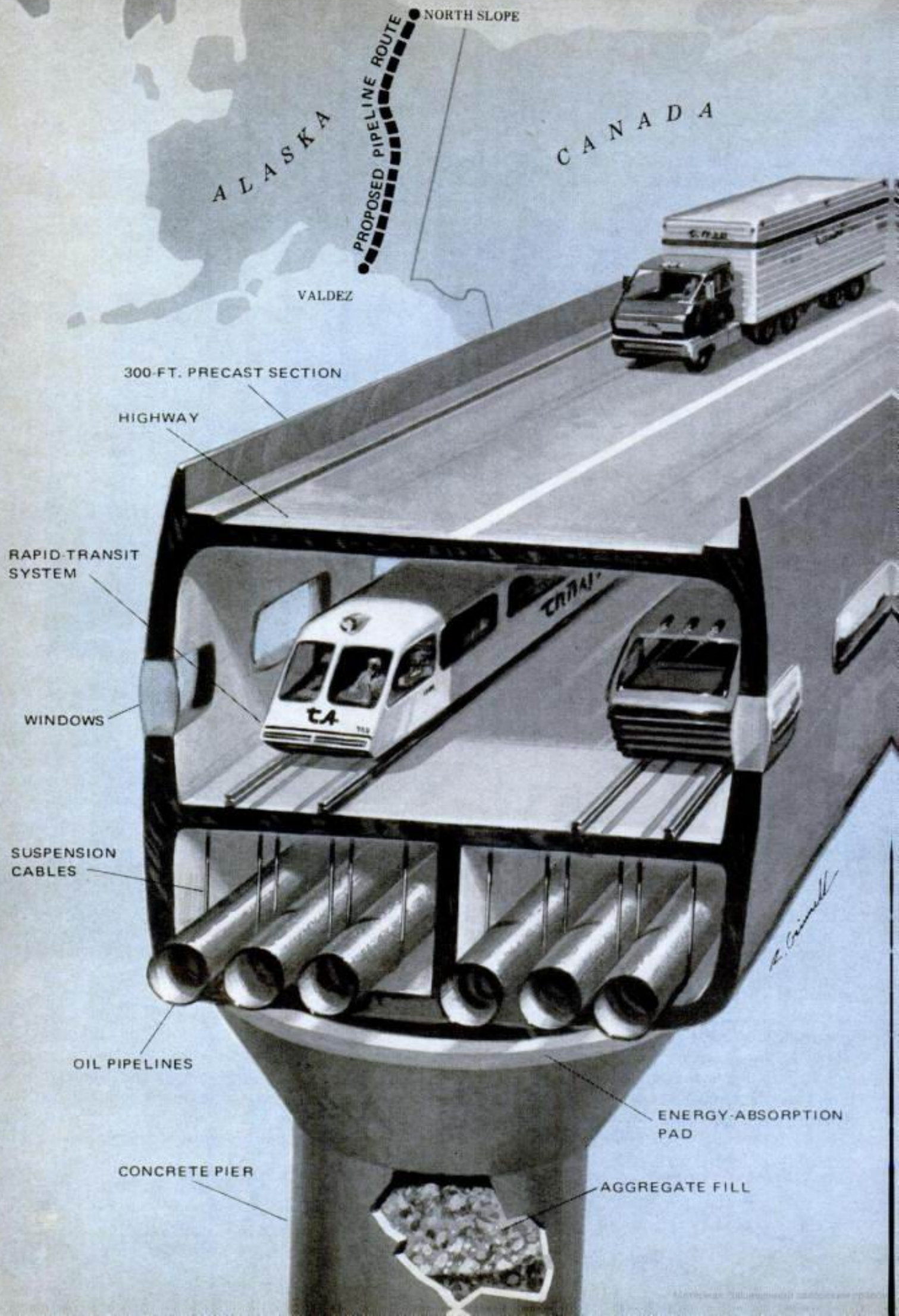
So that land and sea action could be portrayed, the battle scene by artist Ed Valigursky shows AWACS at a much lower altitude than it would normally operate

In its air-defense role, AWACS will extend radar surveillance hundreds of miles beyond U.S. borders. The Air Force doesn't say just how far. In times of low tension, AWACS picket planes could remain on ground alert. OHR-B (Over the Horizon Radar—

Backscatter) monitors could pick up bogies approaching. A signal would scramble the AWACS crews. Once airborne, AWACS immediately enlarges its area of surveillance as it speeds to its lookout station. During periods of high international tension, AWACS would remain on airborne alert.

Dual-purpose equipment will permit

(Please turn to page 198)



ALASKA

CANADA

PROPOSED PIPELINE ROUTE

NORTH SLOPE

VALDEZ

300-FT. PRECAST SECTION

HIGHWAY

RAPID TRANSIT SYSTEM

WINDOWS

SUSPENSION CABLES

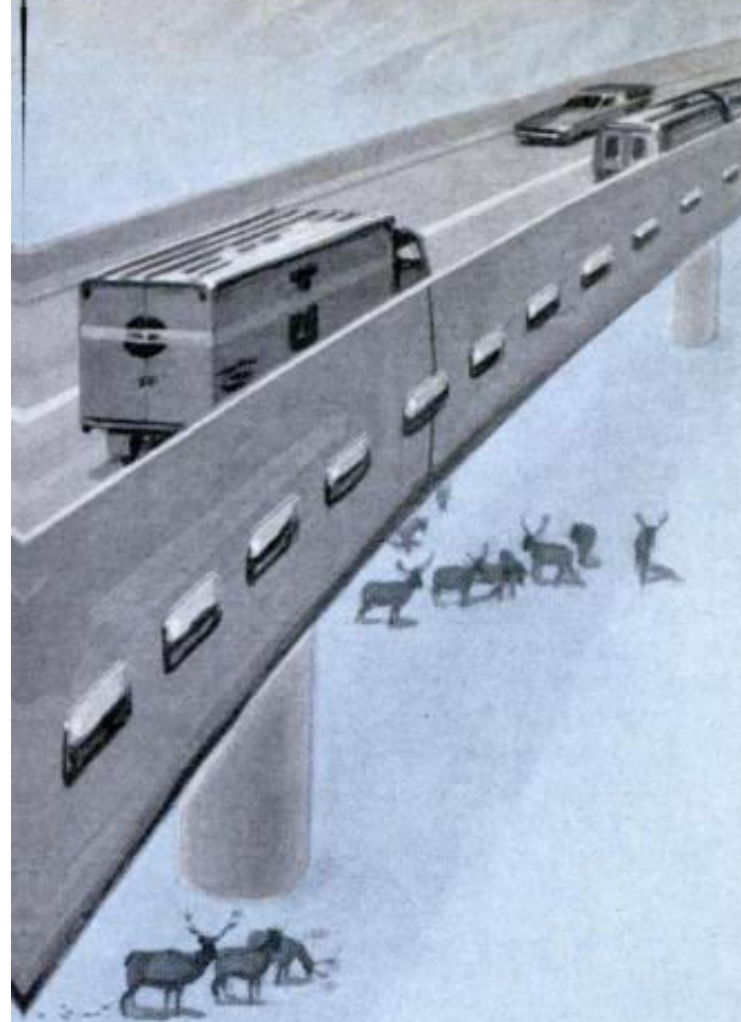
OIL PIPELINES

CONCRETE PIER

ENERGY-ABSORPTION PAD

AGGREGATE FILL

R. Grinnell



Bold proposal: A bridge for Alaskan oil

A concrete tube for pipelines and rail system would save the arctic tundra, says a noted engineer.

by Ed Christopherson

The huge oil reserves on Alaska's North Slope—estimated at from 10 to 30 billion barrels—have bred controversy since their discovery in 1968.

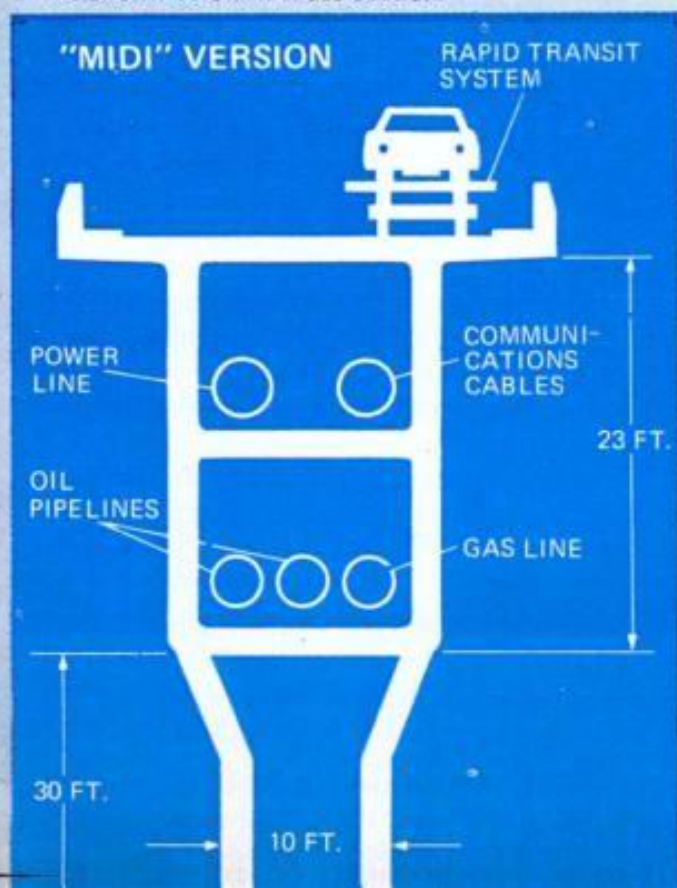
Because Prudhoe Bay is icebound for most of the year, the oil can't be taken out by conventional tanker. Thus, the oil companies developing the area plan to build the Trans-Alaska Pipeline System (TAPS) to move the crude across the state's landmass from Prudhoe to the ice-free port of Valdez—on the Gulf of Alaska about 100 miles east of Anchorage. From there it would be shipped to the lower 48 states.

For years, oil men and ecologists have been at loggerheads over the proposed pipeline. At this writing, it seems the oilmen, with an assist from the energy crisis, have all but won the battle. Bills to permit the building of a pipeline have passed both houses of Congress.

By the time you read this, it's likely that the President will have signed a bill into law.

But that won't keep the environmentalists quiet. They warn that the pipeline could damage the permafrost through heat transfer, cause further pollution through oil leakage and obstruct the migration of the caribou. The relatively untouched Alaskan en-

Two levels of traffic would be accommodated in the "Maxi" configuration of the Integrated Pipeline Transportation system. Top-level highway could be converted to a second rail system. More modest version of the IPT is shown below in cross section.



789-mile bridge . . . 30 feet above ground

vironment could be seriously affected—and not for the better.

Is there an alternative?

Perhaps the most imaginative and comprehensive proposal is the Integrated Pipeline Transportation (IPT) system, the brainchild of T.Y. Lin, a Chinese-born civil engineer recognized as one of the world's leading designers of prestressed concrete bridges and buildings. Lin is on the faculty at the University of California, Berkeley, and a busy consultant.

The TAPS approach represents conventional engineering and, to Lin, is "yesterday's way to build an oil pipeline."

According to the Department of the Interior, which has the responsibility of okaying the pipeline, about half the length of the 789-mile TAPS pipe would be buried, the other half supported above ground at heights of from two to eight feet.

In contrast, the IPT would be a tubular concrete structure supported at 300-foot in-

Big tube could accommodate as many as six pipelines and also function as a transportation artery.

tervals by bridge-type piers. The big tube could accommodate as many as six pipelines and could also function as a transportation artery. Its upper deck, or decks, could be used by autos, trucks and/or an electrified rail system.

In effect, the IPT would be a 789-mile bridge from Prudhoe to Valdez 30 feet above ground along its entire route.

If you ignore environmental aspects, a conventional pipeline seems the cheapest and best solution to the need of getting Alaskan oil to market. But when the land is the Alaskan Peninsula, and the route crosses three mountain ranges, 350 rivers and streams, and runs through permafrost and across earthquake faults, the project becomes an engineering nightmare.

The climate is hostile. In the extreme north, the sun is not seen for almost two months a year. Temperatures can drop to minus 80°F. in interior areas and winds of 40 mph are common.

Permafrost is the name for soil and sedi-

ment, often with a high water content, which in the arctic becomes perpetually frozen ground. At the northern oil fields the permafrost is some 2000 feet thick but thins out further south, eventually disappearing.

Permafrost is stable but, environmentalists say, will melt from the heat of the 140°F. oil pumped through a pipeline such as TAPS. (The oil must be warm to keep flowing.) In that event, sections of the pipeline would eventually be floating in a slurry instead of being supported by anything solid.

Ice wedges—massive vertical veins of ice which form tight polygonal networks invisible from the surface and difficult to delineate through borings—are another widely distributed permafrost hazard. The thawing of ice wedges, according to a U.S. Geological Survey study, could also cause settling, resulting in shearing stresses in the pipe.

Shearing stress—a term for forces that can snap a pipeline—also can result from earthquakes. Seismic vibrations could cause loosely packed sands and silts to liquefy, leaving stretches of pipeline unsupported.

This possibility becomes a serious threat to a pipeline with a route that crosses seven fault zones, three of which are highly active. Hundreds of earthquake shocks are noted in Alaska every year. Much of the \$300 million damage of the 1964 Alaskan quake occurred in the vicinity of Valdez, the southern terminal of the TAPS line.

In an attempt to limit the size of possible oil spills, TAPS engineers have included a system of check and block valves so no more than 64,000 barrels of oil are likely to escape from any point in the system.

In spite of elaborately detailed contingency plans to staunch and clean up oil spills, pipeline leaks could do serious damage to vegetation and streams, and destroy important fish spawning grounds hundreds of miles downstream.

Lin's IPT system is designed to avoid or contain the various hazards. Permafrost is no obstacle to IPT construction because in its frozen state it provides a solid, rock-like bearing. Fifty-foot pier holes would be sunk with rock-drilling rigs with 10-foot-diameter bits. When a hole is ready, the pier—a

(Please turn to page 182)

STEEL LAUNCHING TRUSS

300-FT. PRECAST SPAN SECTION

PRECAST CONCRETE PIER

SHAFT-DRILLING RIG

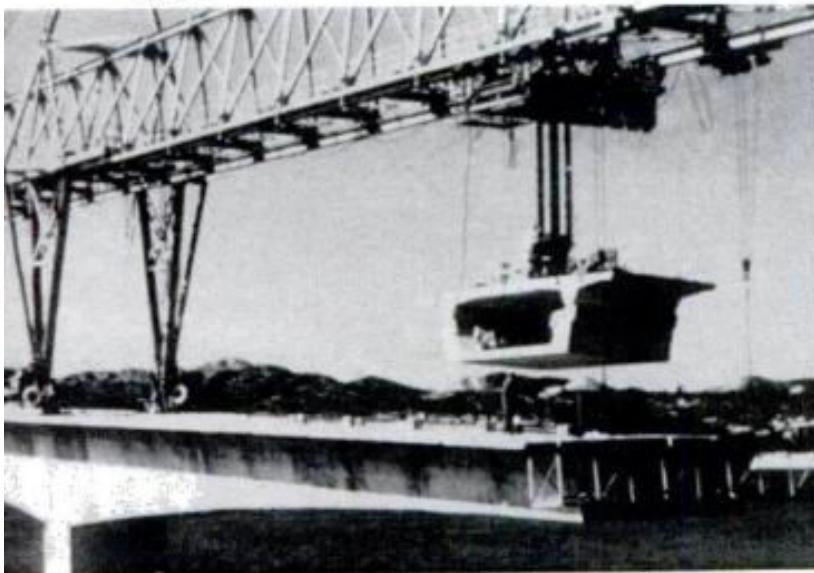
LARGE-DIAMETER BIT

CONSTRUCTING IPT SYSTEM

A method similar to that used in launching bridges over rivers would be employed. A cantilevered steel truss moves forward as construction progresses, dropping piers into 50-foot holes and easing precast span sections into position. Both piers and span sections would be fabricated at plants located at 40-mile intervals along the route. The launching truss and the fabricating plants would be weatherproofed for year-round operation in Alaska's rugged climate.



Special drilling rigs such as that shown in drawing could be used to dig the holes required by the big piers. In soft ground, large-diameter holes can be drilled in a single operation, though this would not be the case in Alaska. Shaft shown above was cut with a 10-foot-diameter auger. The bridge-launching method the inventor proposed for his IPT system is seen in operation (left) during the construction of a river-spanning bridge in Italy.



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YOUNG MECHANICS:
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A DREAM SPANNING CENTURIES

by Gurney Williams III

While some engineers map plans to battle deterioration in old bridges, others carry on a centuries-old dream of building new and longer spans, some of them stretching over threatening waters.

The dream is at least as old as the world's first iron bridge in Shropshire, England (see opposite page). Exactly two centuries after iron smelters completed its superstructure, it still arcs today over the 100-foot-wide River Severn, its cast-iron components slotted together with dovetail joints.

Among the most innovative descendants of that durable iron bridge are the designs of T. Y. Lin, a California engineer. Lin's "Peace Bridge," shown in an artist's conception on these pages, is designed to link the U.S. with the Soviet Union across the 50-mile Bering Strait from Alaska to Siberia. During prehistoric times, the strait was dry, providing a corridor for migration between Asia and North America. Today the waters are challenging: Ice floes up to six feet thick migrate with the currents during certain seasons. And they're potential battering rams—bearing forces of thousands of tons—against bridge piers.

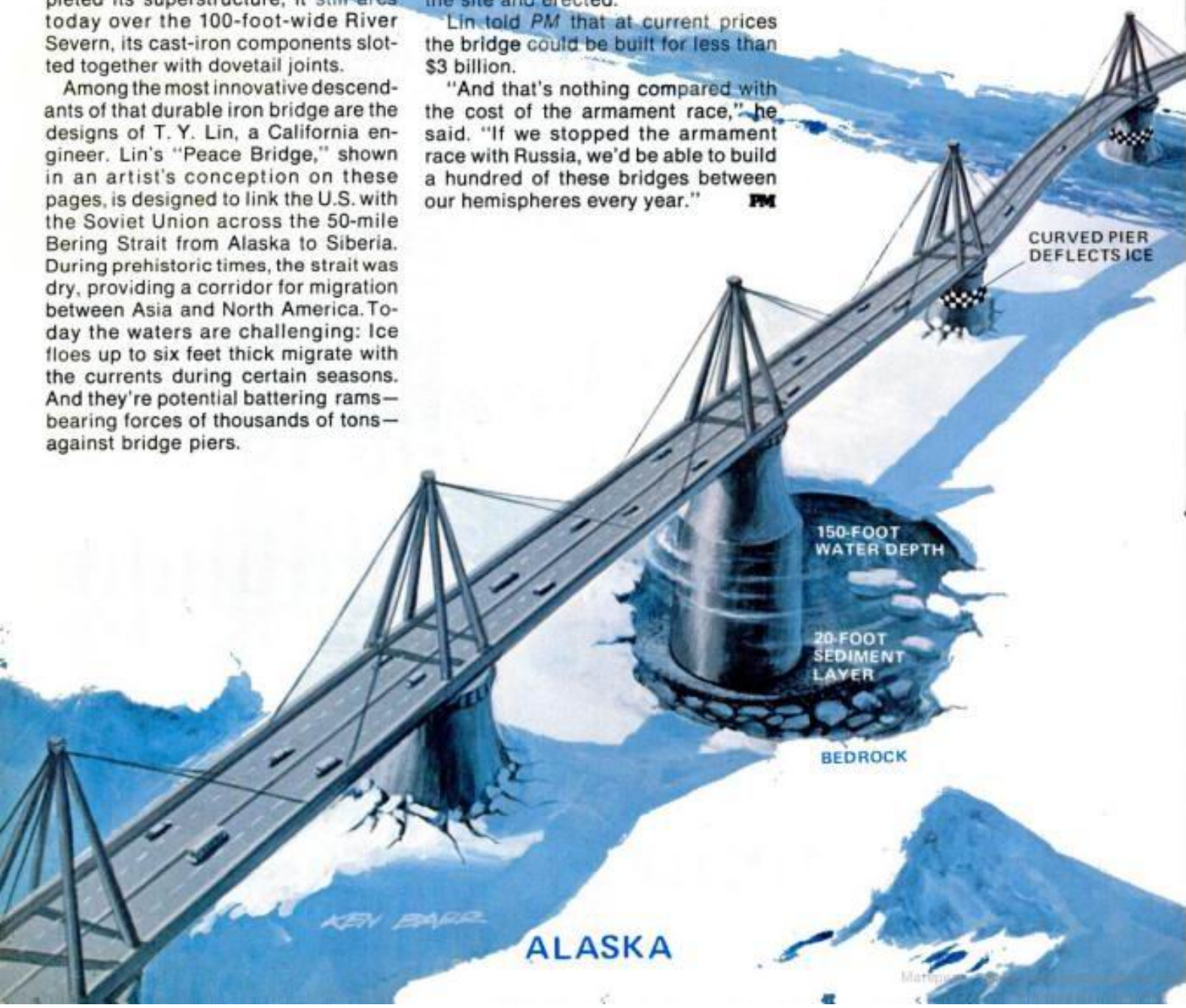
But Lin's design includes smoothly curved piers so that advancing floes are deflected harmlessly upward. And in other respects the engineering problems of the "Peace Bridge" are surmountable. Water depths, for instance, average a modest 150 feet, with a maximum of 180 feet. The bridge would be prefabricated in 1000-ft., steel-and-concrete sections, barged to the site and erected.

Lin told *PM* that at current prices the bridge could be built for less than \$3 billion.

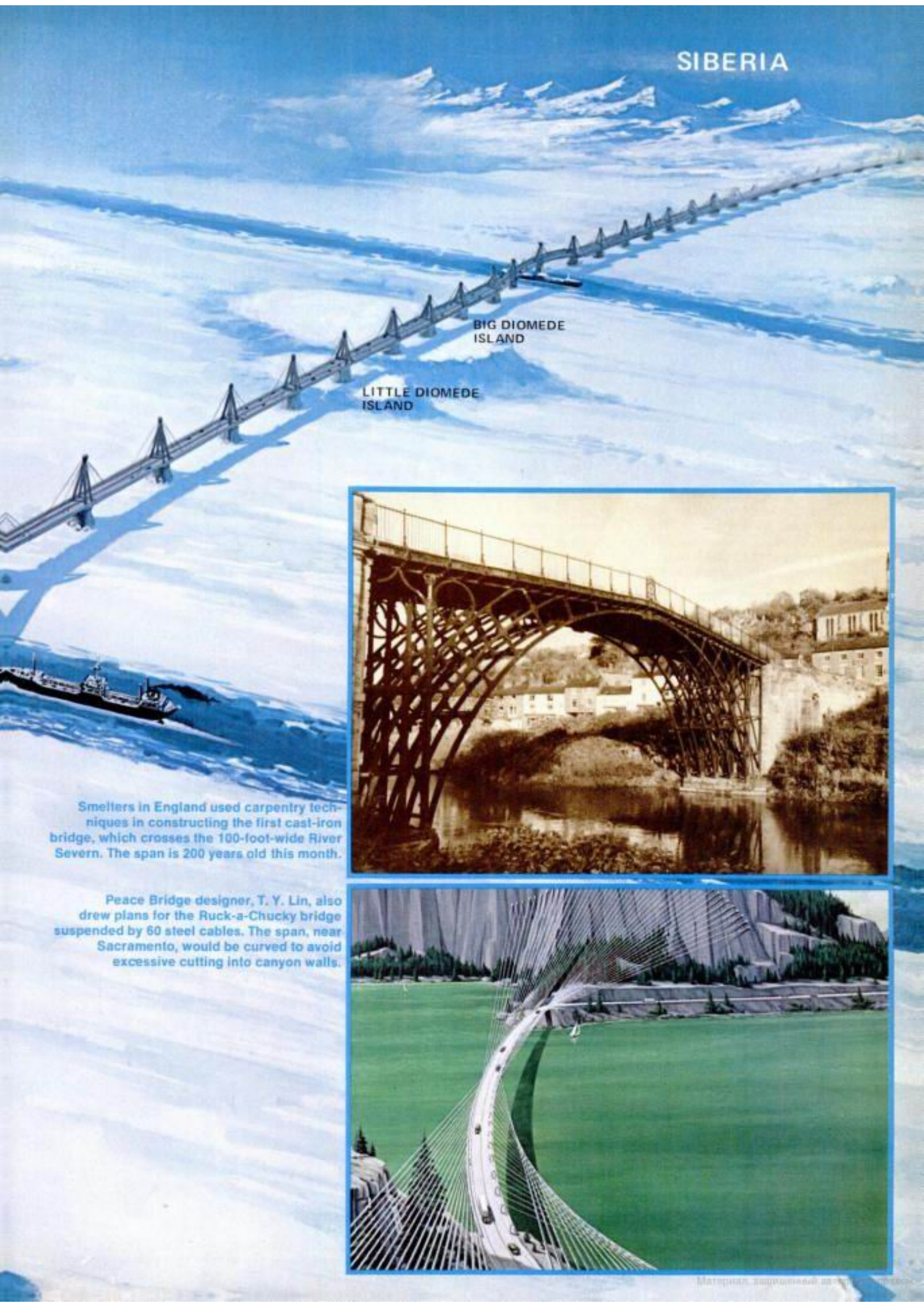
"And that's nothing compared with the cost of the armament race," he said. "If we stopped the armament race with Russia, we'd be able to build a hundred of these bridges between our hemispheres every year." **PM**



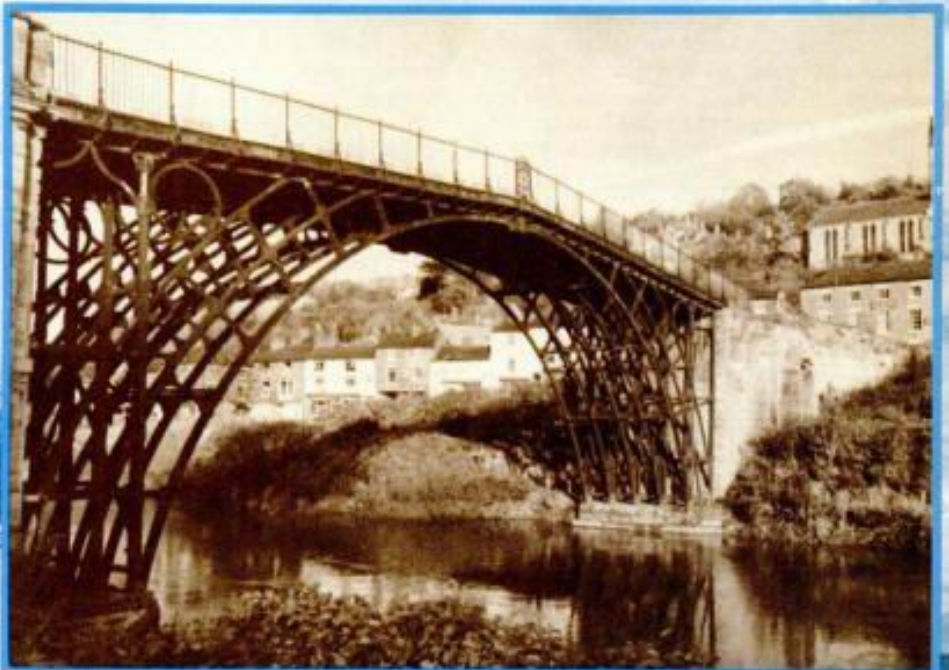
Peace Bridge would cross International Date Line dividing 50-mile trip between U.S. and U.S.S.R.



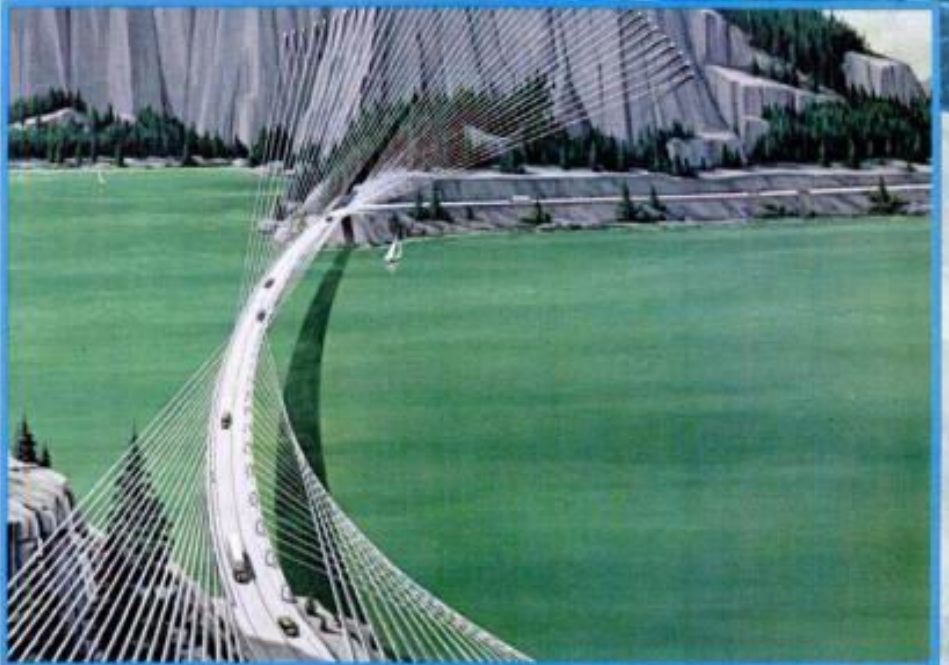
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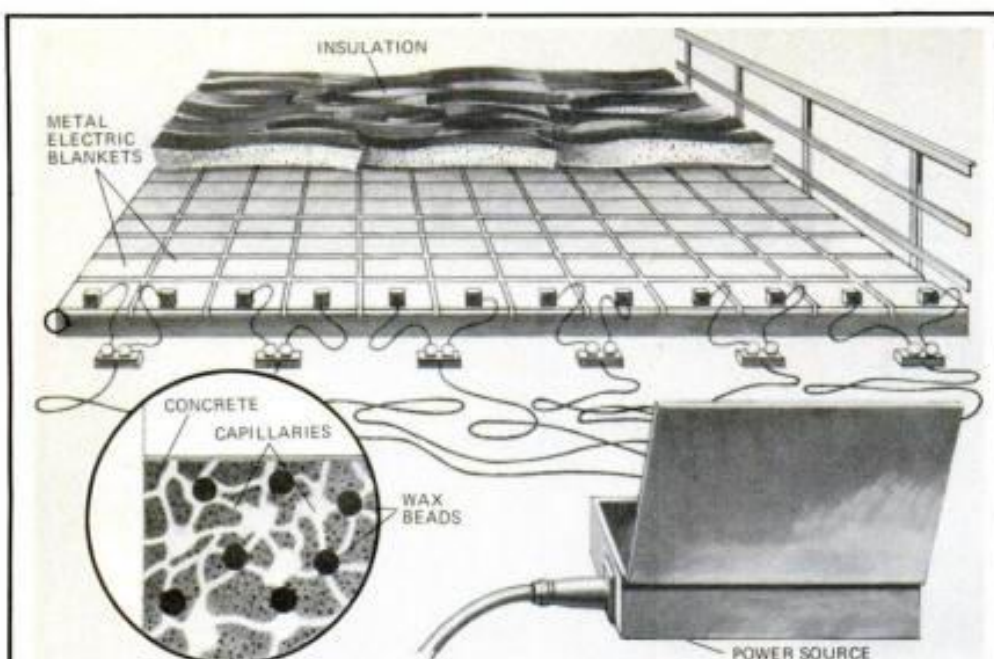


Smelters in England used carpentry techniques in constructing the first cast-iron bridge, which crosses the 100-foot-wide River Severn. The span is 200 years old this month.



Peace Bridge designer, T. Y. Lin, also drew plans for the Ruck-a-Chucky bridge suspended by 60 steel cables. The span, near Sacramento, would be curved to avoid excessive cutting into canyon walls.

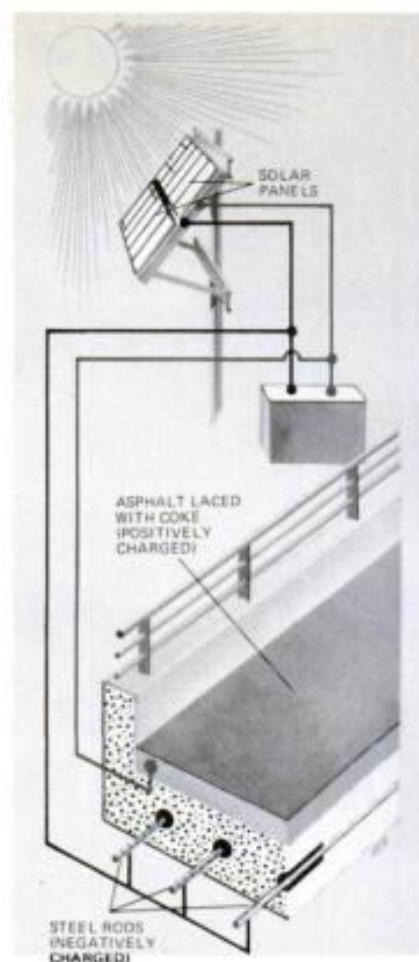




3 ways to save a bridge: Wax it, electrify it . . .

Salt used to melt winter ice seeps into tiny cracks, combines chemically with steel supports. Steel then expands, cracking bridge structure. One experimental solution: 2-inch layer of concrete atop bridge deck (above) seals surface when wax

beads inside layer are melted, plugging capillaries. In another test (right), solar panels give steel a negative electrical charge, driving off negatively charged chloride ions, the steel-eating component of dissolved salt.



years before it finally collapsed in 1970 under the weight of city trucks trying to repair it. Rotten wood and rusting metal are commonplace, and cities can't afford repairs.

■ Snow- and ice-removal tactics have ravaged bridges.

■ Most of the bridges simply weren't made for the loads they are

now carrying. They were designed, instead, at a time when no one foresaw the explosion of highway transportation, especially the trucks, farm equipment and school buses which are carrying bigger and heavier loads.

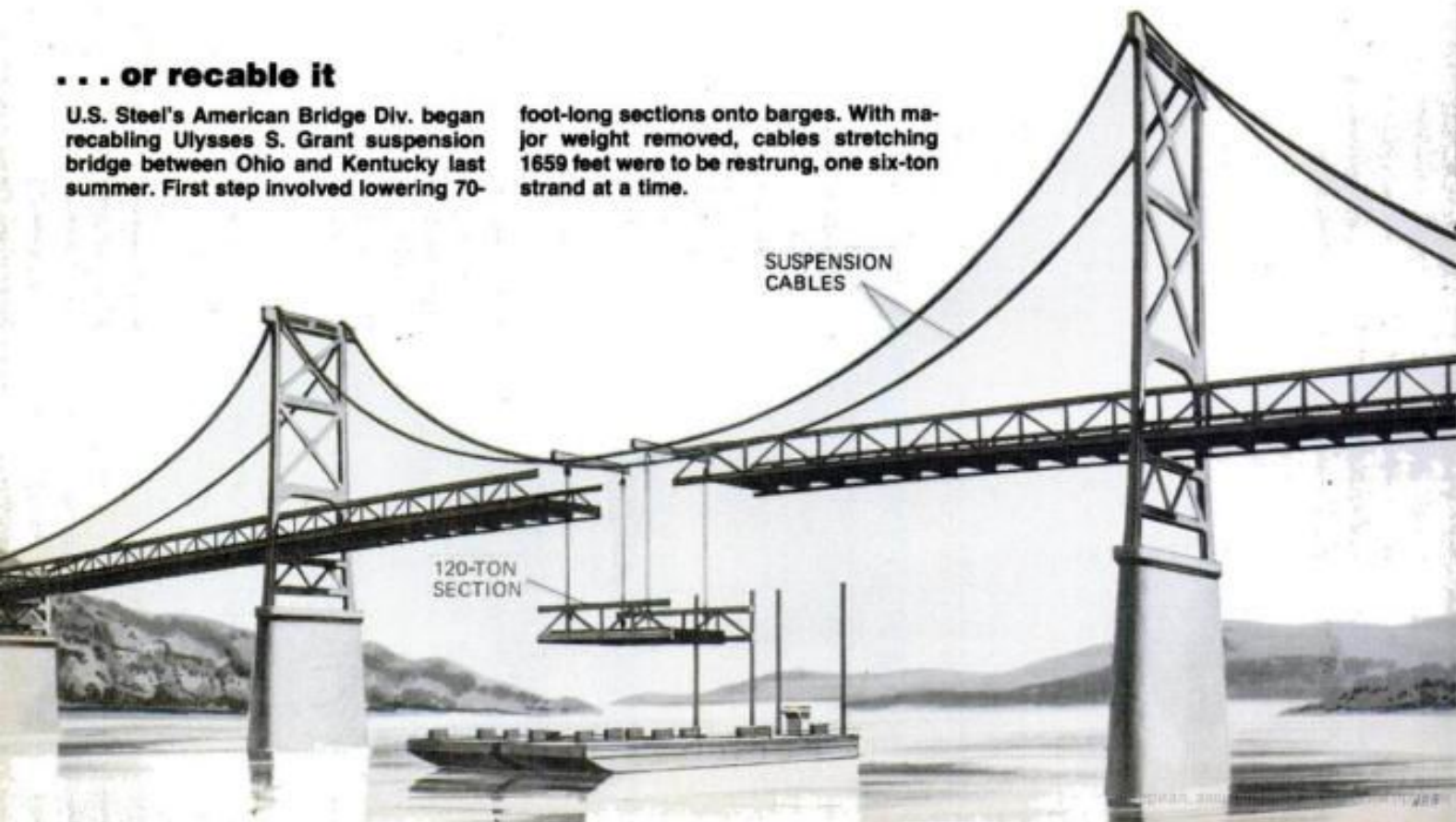
But it doesn't take a truck to batter an old bridge. Consider the bi-

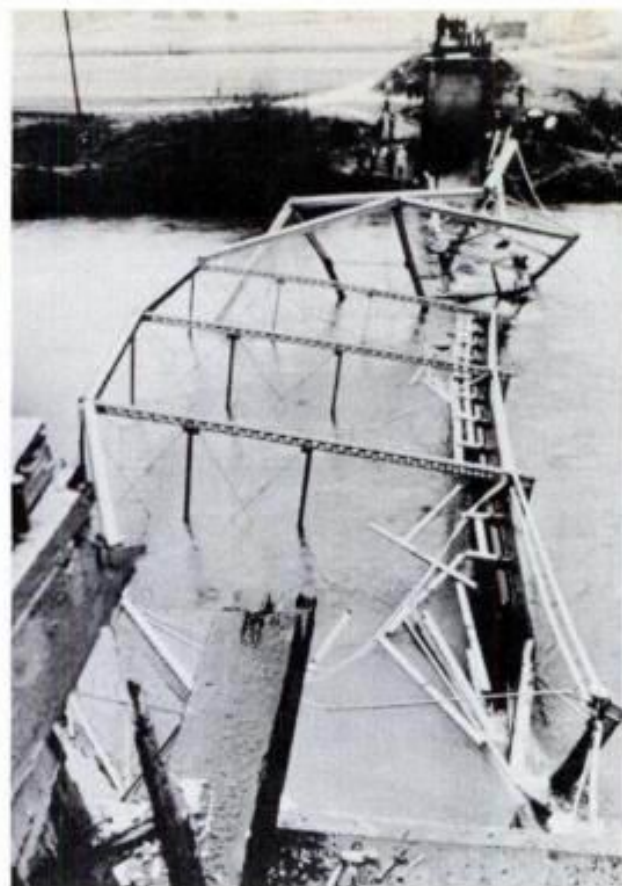
zarre case of James Venable, a real estate agent in North Carolina. Venable was driving home one foggy night in February 1975 when he came to the narrow Yadkin River bridge near Siloam, N.C. The country bridge, running about 30 feet above the black, swirling river, had been in place since 1938.

. . . or recable it

U.S. Steel's American Bridge Div. began recabling Ulysses S. Grant suspension bridge between Ohio and Kentucky last summer. First step involved lowering 70-

foot-long sections onto barges. With major weight removed, cables stretching 1659 feet were to be restrung, one six-ton strand at a time.





After Yadkin River bridge fell one foggy night, cars continued to drive off bare piers. Four people died.

The fall of the Yadkin River bridge



State-commissioned report blames collapse on collision of one car with southwest end post. But driver of car argues that bridge began to go down just after he drove onto 225-foot-long deck.

Venable drove his white Thunderbird up the cattle-shoot entrance to the span, entering the 225-foot-long deck across the river. He had gone about two car lengths on the deck, he recalls, when the car was thrown against the right side of the bridge. His head struck the left window.

"I hit the brake and tried to pull the car away from the right side," Venable told PM. "I couldn't do it. Then it hit on the left side. I looked up at the overhead trusses. They were leaning and moving around. The damn bridge was going down while I was on the middle of the span. The last thing I remember, I was bewildered because the car wouldn't stop. I passed out. When I woke up, I was sitting in icy cold water, in the dark, with my seat belt on."

Venable had no idea what had happened, but he knew he was in grave danger. The windows and doors wouldn't open and the water was chest high. He reached under the water and undid his seat-belt, then pulled himself over the seat and kicked the back window out. He then thrust his chest out over the trunk.

Lying across the tail of his car was a Mustang, wheels in the air. Two girls who had been in the overturned car had managed to escape and now they stood on the trunk of

Venable's Thunderbird, the river rushing around them. "Are you hurt?" they asked.

"Help me," Venable said. But there was little they could do. Venable, who weighed 225 pounds, was stuck in the window. When the girls tried to pull him out, the glass remaining in the window frame began cutting into him. He pulled a pocket-knife from his pants and tried to hack away the back-seat padding to free himself. The knife slipped out of his fingers.

"About that time I looked up and saw a car falling from the opposite side of the river," Venable said. "You could see the lights through the fog, starting level, then curving down toward the river. And right behind it another car came in, the same way, and you could hear the screaming and booming. And I thought 'It's like chariots of death.' I pulled everything in me to escape from my car, and I squeezed out."

Venable didn't know the scope of the terror until much later, after he had swum down river, pulled himself up the bank and met rescuers. The entire bridge had fallen into the water. In all, seven vehicles soared off the piers and dropped the 30 feet into the river. Sixteen people were injured. Four others died.

Why did it happen? There are two explanations. Whichever you ac-

cept, the incident is indicative of the dangers of older bridges. Venable's story is that a storm-weakened span began to fall as he crossed it. A state-commissioned report by consulting engineers who analyzed trusses fished from the water presents a different version: Venable's car, in their opinion, ran into the southwest end post of the bridge,

'I was bewildered because the car wouldn't stop. I passed out. When I woke up, I was sitting in icy cold water . . .'

—James Venable

causing several parts of the structure to snap. In simple terms, summarizing the report, a single car knocked down the old Yadkin River bridge.

The toll might have been much higher if the span had been carrying urban traffic. In fact, the potential for such nightmares is every bit as high in the nation's cities as it is on farmland routes: During the past two decades of urban renewal and the rebuilding of entire neighborhoods, bridges have sagged behind.

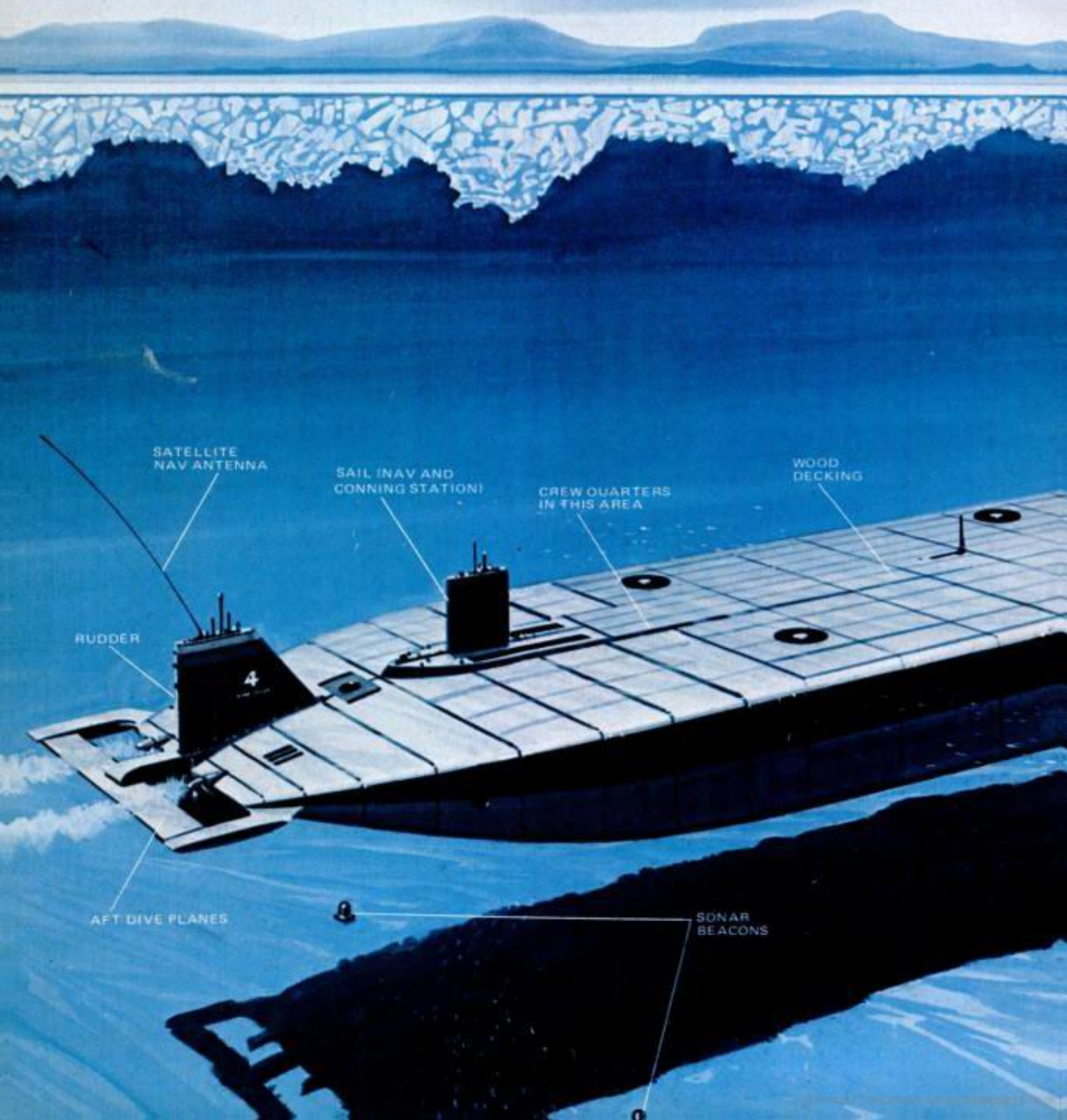
"I feel like a white corpuscle chasing infection," John Drake, Pitts-

(Please turn to page 152)

THE ICE ABOVE THE GIANT' BELOW

Can a steam-powered submarine, over a quarter-mile long, safely carry 60,000 tons of volatile liquid natural gas from Alaska to Europe at a profit? Its designers are betting it can.

by Robin Nelson

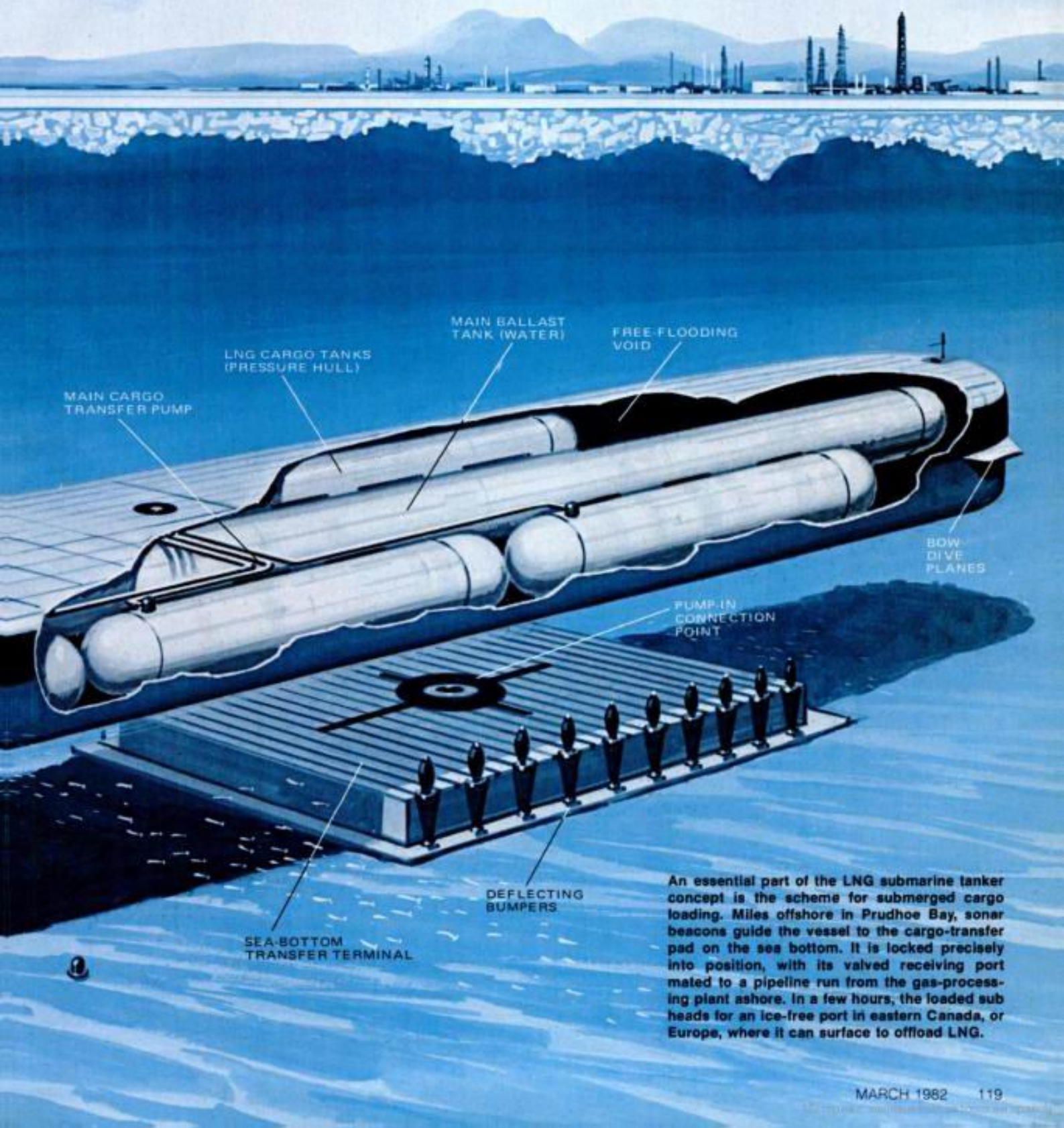


Like science fiction? Imagine a submarine with a hull 90 feet deep, and 140 feet wide for most of its length, which is, maybe, a little more than a quarter of a mile. Go completely wild and deck it with oak beams 10 by 10, sheathed in plywood. Then fill it with enough natural gas—compressed into a liquid for cryogenic storage at under

—260°F.—to incinerate a medium-sized city in one instantaneous fireball. Like it so far? Then put in a methane-fired boiler, or even a nuclear reactor, to charge a turbine with enough superheated steam to drive two massive screws. Now, navigate the whole thing from Alaska to eastern Canada or Europe *under the Polar icecap!*

If you find it hard to take, even as sci-fi, you'll be happy to know that it's an entirely down-to-earth, dead-serious proposal from a group of marine architects, engineers and planners who already have produced fleets of both nuclear submarines and liquid natural gas (LNG) ships—many in service for more

(Please turn to page 182)

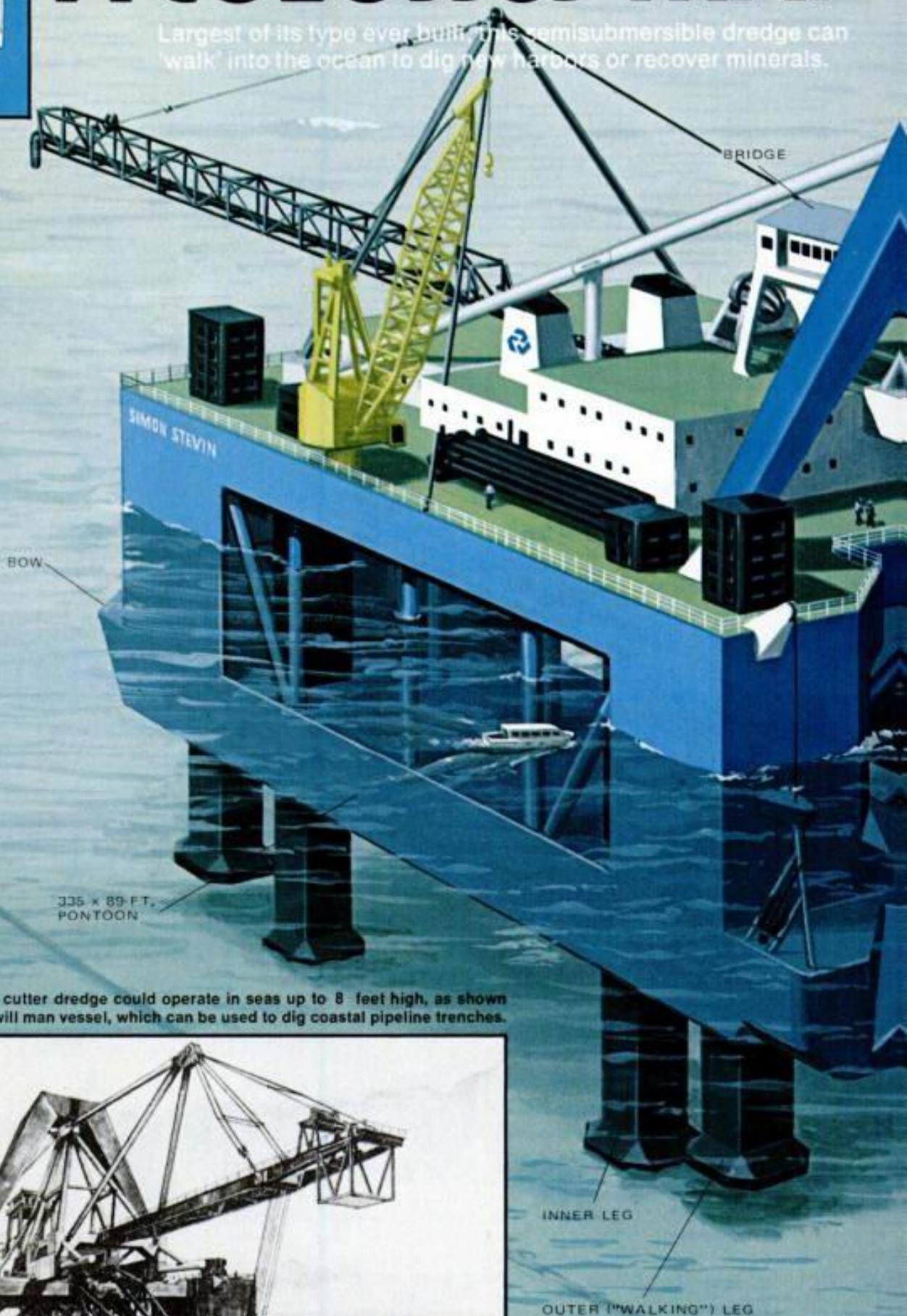


An essential part of the LNG submarine tanker concept is the scheme for submerged cargo loading. Miles offshore in Prudhoe Bay, sonar beacons guide the vessel to the cargo-transfer pad on the sea bottom. It is locked precisely into position, with its valved receiving port mated to a pipeline run from the gas-processing plant ashore. In a few hours, the loaded sub heads for an ice-free port in eastern Canada, or Europe, where it can surface to offload LNG.



A COLOSSUS THAT

Largest of its type ever built, this semisubmersible dredge can 'walk' into the ocean to dig new harbors or recover minerals.



Recently launched cutter dredge could operate in seas up to 8 feet high, as shown below. Crew of 65 will man vessel, which can be used to dig coastal pipeline trenches.



STANDS UP TO THE SEA

Built in Holland for the Volker Stevin Dredging firm, the 620-foot (boom tip to boom tip) *Simon Stevin* is classified as a semisubmersible cutter dredge and is the largest ever conceived. A 5000-hp engine powers its cutting head, which can handle almost any hard soil or rock

except basalt or granite. Its retractable-leg system enables the vessel to stand firmly on the sea bottom and maintain dredging operations in ocean swells up to 8 feet high or more. This means that new harbors—up to 105 feet in depth—can be dredged in areas where wave action previously rendered such facilities unthinkable. A ram-and-hinge system enables the vessel to “walk,” taking 10-foot steps on its outer legs, at up to 80 feet per hour. Ballast pumps regulate its buoyancy and the pressure exerted on the sea bottom; floating free with legs retracted, it can make over 5 knots on its own power—four screws each driven by a 2500-hp engine. **PM**



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NORTH SEA:
DEADLIEST
CHALLENGE
TO OIL
HUNTERS



VALIZURSKY

Patrolling the pipeline at the bottom of the North Sea

Hundreds of feet deep, divers trust
their lives to high technology

by Jack Carroll

Ungainly looking yellow submersibles like this one ferry crews back and forth from the oil-rich sandy sea bed. Subs can track buried pipeline and "fly" courses with military precision.

Buchen Field, North Sea, 58° N. Latitude, 0° Longitude.—Aboard *Intersub Two*, a support vessel, mechanics prepare the ungainly looking, 22-foot-long yellow submarine for the day's first dive. My first dive.

The sea has relented from the previous day's Force 7 condition—near-gale winds with waves up to 14 feet—to a benign, almost unnatural smoothness. To the hum of electric motors, the submersible moves in a cradle from the security of the *Intersub Two* hangar to the afterdeck. There, the crew hooks on





main hawser and secondary lines from the giant A-frame launching crane.

I climb the oil-slippery ladder to the tiny conning tower. And with a passing thought about claustrophobia, in we go. Tony Miller, a 2000-hour sub pilot commanding this mission, advises me to crawl back into the rear compartment; in other words, stay out of the way. It's a chin-on-knees situation, made even more cramped by the black boxes and electronic gear that crowd the 41-inch width of the vessel's pressure hull.

This rear compartment is normally occupied by two divers and sealed off from the front compartment. But today's mission will not involve divers, so I have the small space to myself.

All set to go

With a slight lurch, the submersible is lifted up and away from the stern of *Intersub Two* and deposited gently into the sea. Now the swimmer from an attending Zodiac inflatable detaches all connecting lines. We're powered up, in communication and ready to go. Miller floods the tanks and we begin the descent,

From cramped quarters aboard a North Sea submersible (above), a diving supervisor monitors the work of men outside. After 3- to 4-hour shifts at 500 feet, divers return to pressurized compartment aboard the sub.



as I get a fleeting, final look at the mother ship through the bomber-like plastic bubble in the sub's nose.

The vessel I'm riding has become an essential tool for offshore engineering tasks, working successfully in the most demanding proving ground of all: the oil-rich North Sea

fields. So rich, in fact, that from the Buchen Field alone, which is considered marginal, BP expects to extract more than 50 million barrels of oil in the next four years.

The submersibles work hard to keep this oil flowing, cruising over pipelines or around drill platforms on inspection missions, aiding deep-

PM photos by the author





Like astronauts tethered to a space vehicle, North Sea divers float near 22-foot-long sub, connected by air, heat and communications lines. Divers inspect and repair drill platforms and pipelines, for fee of about \$460 per day

sea surveys, ferrying divers. The small subs perform these tasks with the help of technology you'd expect to find only on much larger vessels. For example, Intersub has developed an inertial navigation system based on military aircraft technology to provide highly accurate, rapid distance and angle measurements.

The Marseilles-based company has also developed a patented pipe tracker allowing the submersible to follow a pipeline buried up to three meters deep.

Intersub's gamble on developing new technology for the oil industry has apparently paid off. The company, which was founded in 1973, has grown from one sub and support vessel in 1974 to a fleet comprising one remotely piloted and 14 manned submersibles, including the one I'm riding now.

"Passing five zero feet," reports T.J. Jaynes, the observer, who is stationed forward with the video monitor and controls for the craft's two

mechanical arms, or manipulators. The sea changes color rapidly, darkening to a sediment-laden green, captured in the glare of the sub's quartz-iodide lamps.

It is 10:21 and all the old late-night television submarine movies never prepared me for this: Calm prevails and there are no sharp commands or anxiety. Just the reassuring whirs, rasps and hums of electric motors and servos. One motor, somewhere, keeps cutting out. Miller instructs me to "Give that box there a good rap when it happens." It works, and it seems I now have a job for the duration of the voyage.

There is little sense of motion as we reach 150 feet at 10:26, 350 feet at 10:29, and our working depth of 376 feet shortly thereafter. The bed of the North Sea—as I had been advised earlier—is unspectacularly



At the end of a dive, swimmer from Intersub support vessel attaches lines (far left), then leaps for safety as swells shove sub perilously close to mother ship.

flat and sandy. But that's where the oil is, and that's why Intersub vessels are here—complemented by some of the best divers in the world.

Saturation divers—the elite

As versatile and useful as the submersibles may be, they're still only machines and lack the dexterity and mobility of humans. So Intersub teams saturation divers with the submersibles, especially for close-in detail work and inspections of drilling platforms.

Divers "in saturation" breathe a mixture high in helium and low in oxygen and, when not out working in the ocean's depths, are "stored" at that same pressure level in a chamber aboard the support vessel. When it's time for work, the two divers on duty (the mother ship's chamber usually holds four divers) suit up and pass through a transfer trunk and lock system. They enter the rear compartment of the submersible—my compartment.

When divers are aboard, the after

section of the sub is "blown down" to a pressure level precisely matching that of the chamber on the support vessel. The sub's pilot, observer and diving supervisor remain in a one-atmosphere environment (the same as you're in as you read this) in the front compartment. From there, they observe, direct and control the divers' activities throughout the mission.

Once the sub reaches the work site, the diver steps out through an airlock with tools, testing probe or camera. Supplied with heat, breathing mixture and communications link through an umbilical cord, he goes to work.

At the end of a shift lasting three to four hours at 500 feet, the procedure is reversed. The divers pass from their compartment in the sub, through the support vessel's airlock and into the confines of the chamber. There, they'll eat, sleep and try to avoid boredom, usually for about 21 days plus 6 days for decompression; sometimes for as long as 48 days.

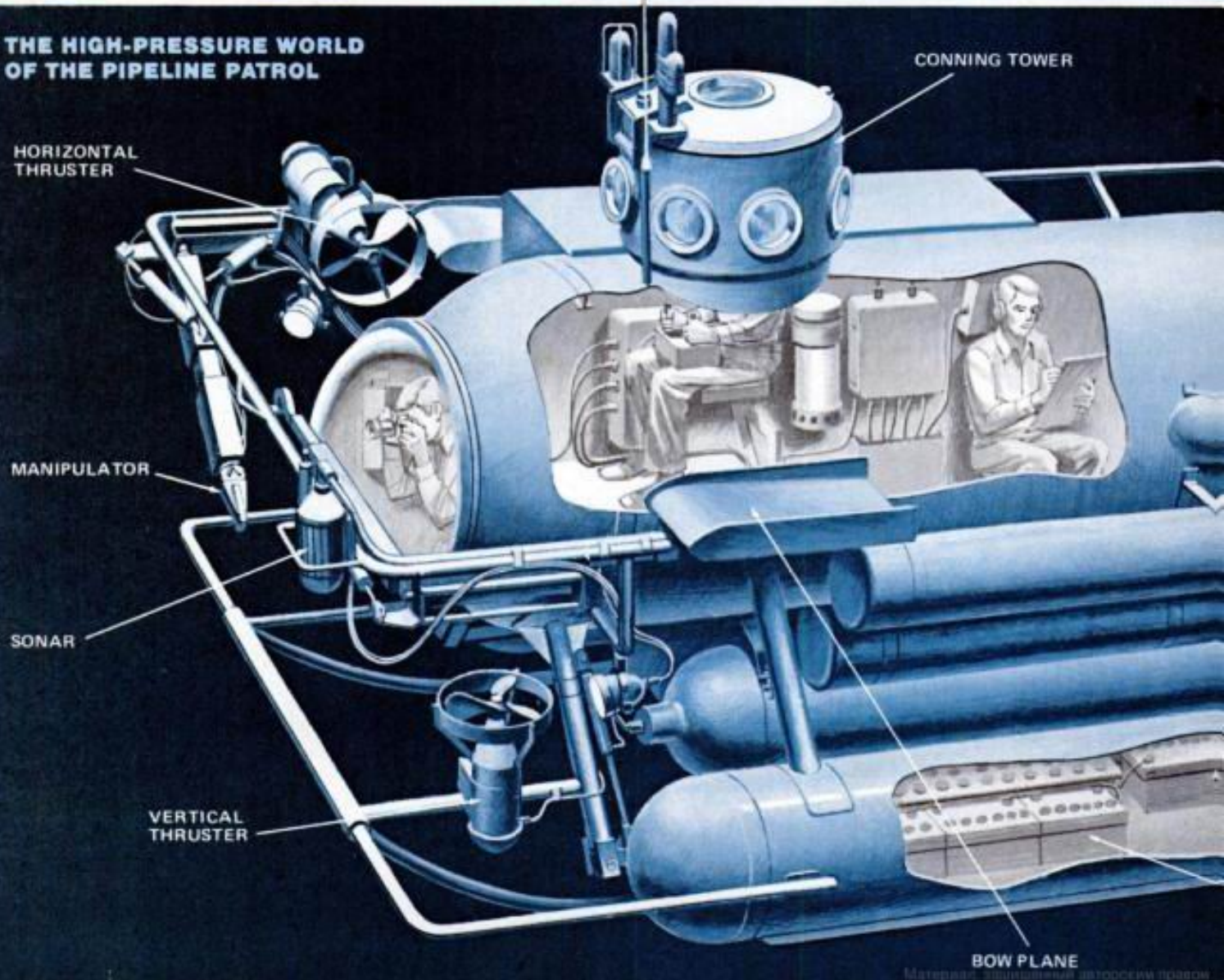
According to Laurie Duffin, a saturation supervisor with Wharton-Williams Ltd., an Intersub diving subcontractor, "There's really not too much of a problem with boredom as long as you're working."

"But when the weather is too bad for operations and all your time is spent in the saturation chamber, it can be difficult, no matter how many books and magazines you have to read." Like any other job, said Duffin, "You get used to it." And, presumably, to the pay, which can amount to approximately 215 pounds or about \$460 per day.

Life in a pressure chamber

While in the chamber, the divers' lives are controlled completely from the outside by life-support technicians who continually monitor the pressure and breathing mixture, control the lock through which meals are passed, and even operate the divers' toilets. Communication between the divers and their operators is made possible by a voice "scrambler" that brings the divers'

THE HIGH-PRESSURE WORLD OF THE PIPELINE PATROL



voices from a helium-induced, Donald Duckish squawk to a more human level. And they'd better get along in their steel prison, said Hartmut Winterberg, a diver with more than 3000 hours in saturation.

"You observe the divers closely in those tight quarters—their personal cleanliness and how they get along with the other divers—so you can stop trouble before it starts. If the friction gets to be too much, we get them out of there as fast as we can." Fortunately, though, divers are a tight little fraternity and most get along accordingly.

Locating a template

After long confinement in a chamber, the high-pressure underwater work is comparatively pleasant. Far below hostile weather, the emerald-colored waters are calm and quiet. And—I'm finding on my North Sea dive—easing through these waters is as smooth and quiet as a glider flight on a clear day.

Our first task is to locate a tem-

plate, a square piece of metal on the seafloor used to mark a drilling site. The sub "flies" just above the bottom and, using its sophisticated inertial navigation system, finds the plate easily—but not before an unexplained communication lapse occurs with the mother vessel. At 10:44, as we're positioned precisely at the template, communications are restored with a matter-of-fact query from the surface: "Where've you been?" An inquisitive cod swims casually into the halo of light in front of the transparent nose blister, pauses momentarily and moves on, perhaps used to these little yellow submarines by now.

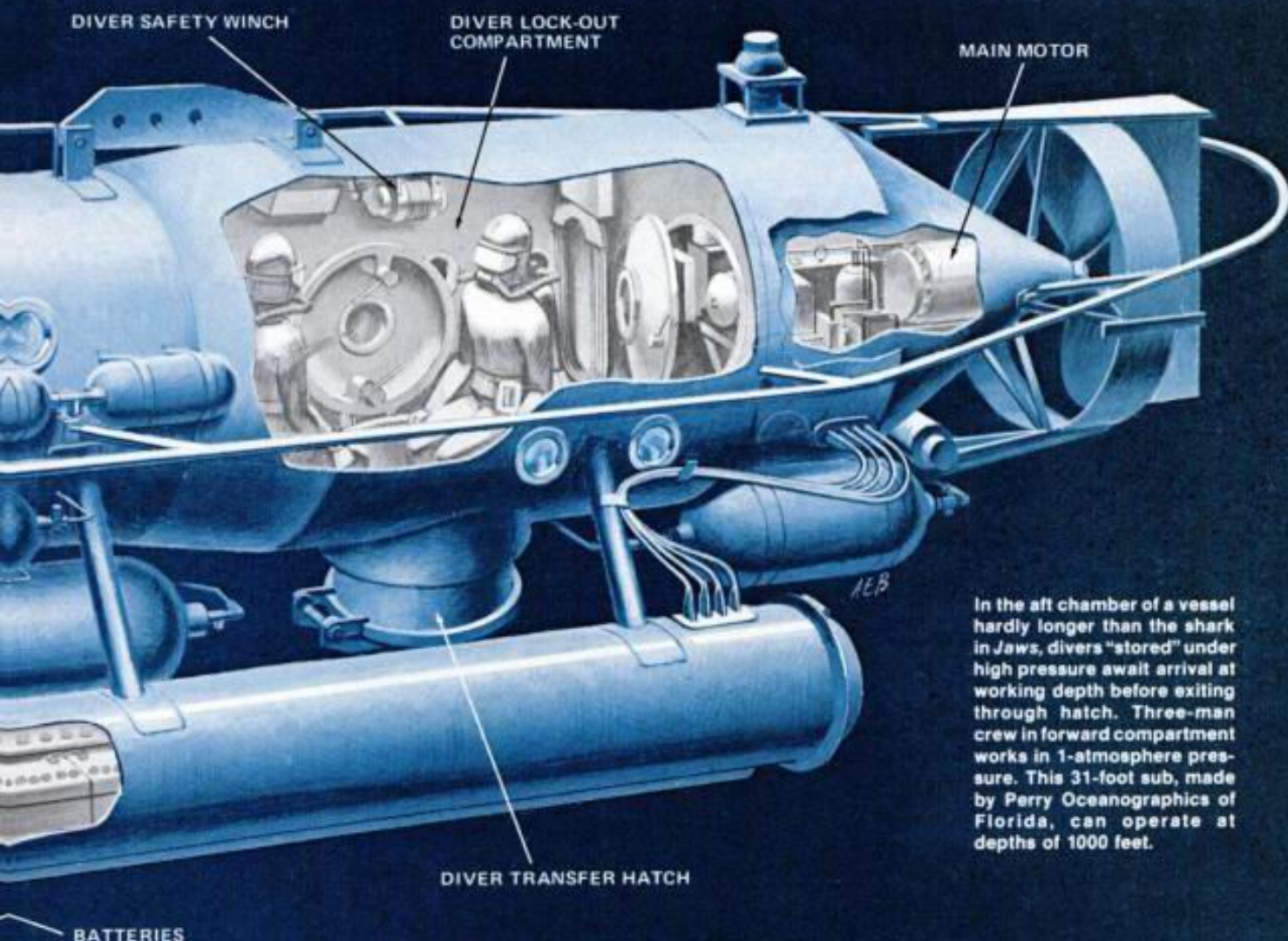
We inspect the template and the pilot begins to fly the sub along a nearly two-kilometer length of 12-inch pipe that leads to a connection with a hose to a surface buoy. As the sub flies over the pipeline, seemingly faster than the stated cruising speed of just one knot, a videotape unit continually covers all objects in the sub's path. Meanwhile, the observer supplements the visual

record with his own running commentary for the benefit of British Petroleum Oil, which is paying for this trip. The picture on the TV monitor flip-flops intermittently, and mission control in the mother ship advises there may be too much light. The problem is never fully resolved on this flight.

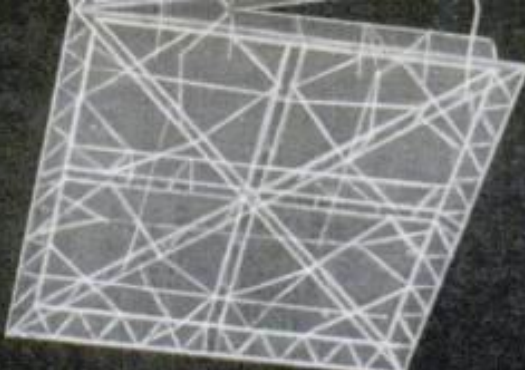
An odd-job request now crackles over the radio speaker: A transponder buoy that should have been released by radio signal, allowing it to rise to the surface for recovery, is hung up. Do we see it, and can we release it? Suddenly, as if on cue, there it is, looking like a bright yellow pencil sticking straight up out of the greenish haze.

The sub hovers efficiently, as observer Jaynes flexes his "muscles"—the sub's manipulator arms. One arm has a clawlike grip. The other holds a mean-looking rotary disc cutter. Jaynes adroitly maneuvers the sub's right arm to grip the transponder's restraining line. But before the disc can go into action,

(Please turn to page 194)



In the aft chamber of a vessel hardly longer than the shark in *Jaws*, divers "stored" under high pressure await arrival at working depth before exiting through hatch. Three-man crew in forward compartment works in 1-atmosphere pressure. This 31-foot sub, made by Perry Oceanographics of Florida, can operate at depths of 1000 feet.



Major de Seversky's *Ion-Propelled Aircraft*

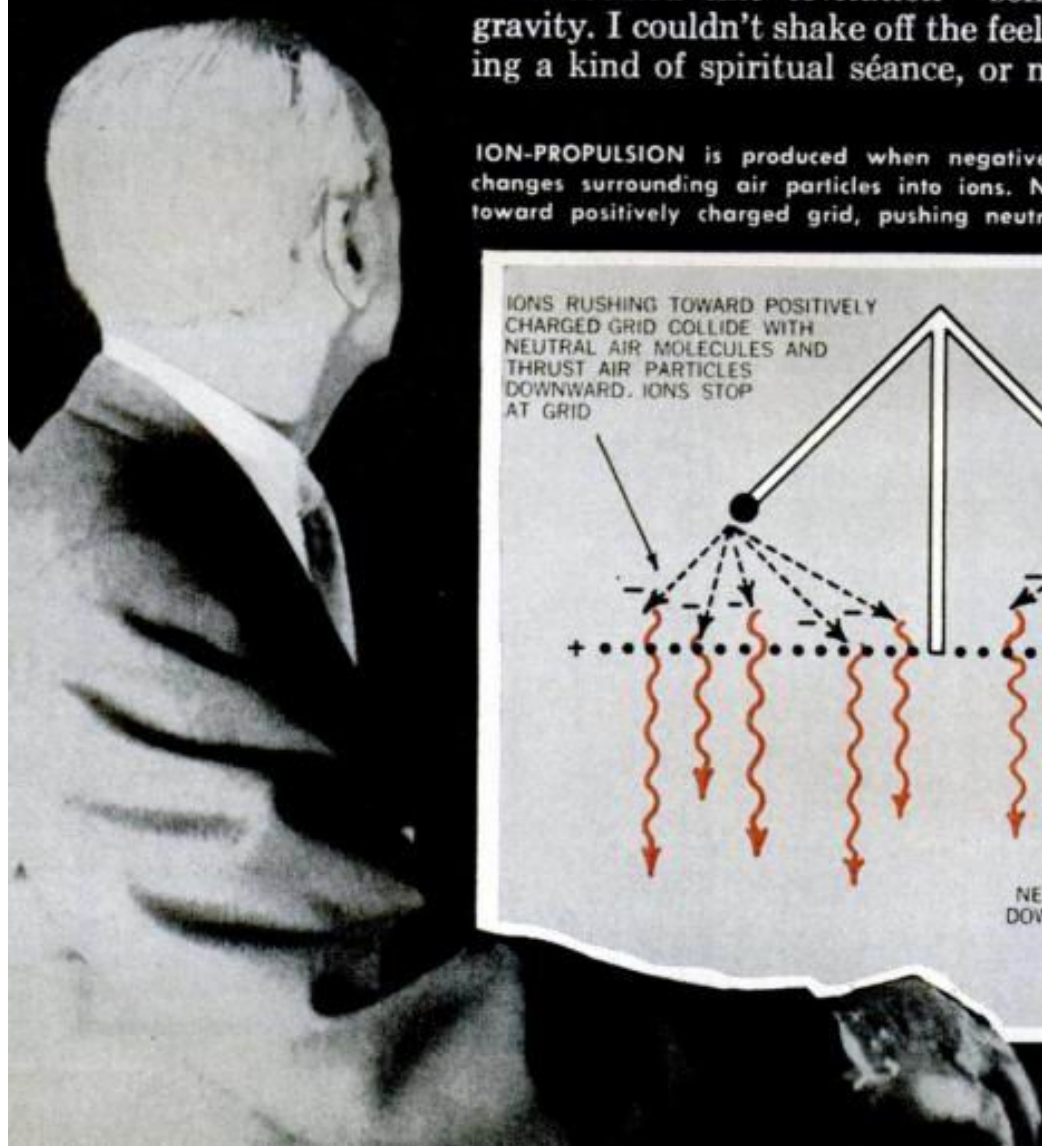
An ion-generated wind will lift and propel this incredible magic carpet of the future

By Hans Fantel

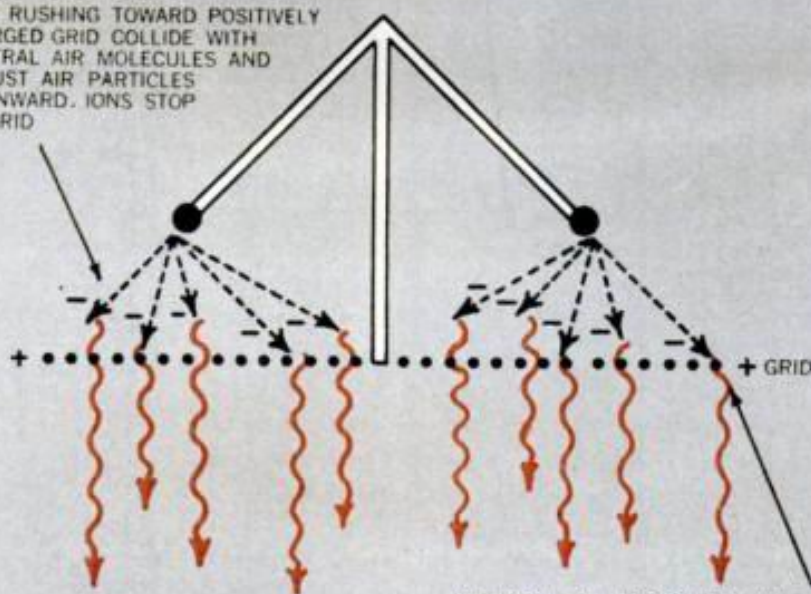
IT WAS DOWNRIGHT SPOOKY. Without a sound, the peculiar, spiky contraption rose straight up, hovered awhile, climbed higher. Then it did a few graceful turns, stopped again, and just sat there silently in midair.

It seemed like levitation — some trick to overcome gravity. I couldn't shake off the feeling that I was attending a kind of spiritual séance, or maybe a Buck Rogers

ION-PROPULSION is produced when negative charge from upright arms changes surrounding air particles into ions. Negatively charged ions rush toward positively charged grid, pushing neutral air particles before them



IONS RUSHING TOWARD POSITIVELY CHARGED GRID COLLIDE WITH NEUTRAL AIR MOLECULES AND THRUST AIR PARTICLES DOWNWARD. IONS STOP AT GRID



NEUTRAL AIR MOLECULES, WHACKED DOWNWARD BY IONS, PASS THROUGH MESH OF ION-ACCEPTOR GRID. DOWNWASH OF AIR KEEPS IONOCRAFT ALOFT

show, instead of an engineering demonstration.

The eerie scene took place in the big, barnlike laboratory of Electronatom, Inc., a research firm in Long Island City, New York, devoted to the development of a new kind of flying machine. I had been invited to watch a scale model being put through its paces by remote control. What we saw was by far the oddest aircraft since the Wright Brothers' motorized kite. It had no prop. No jet. No wings. In fact, it had no moving parts at all. Looking somewhat like an old-fashioned bedspring, the rectangular rig is the nearest thing to a magic carpet. It needs no runway, takes off vertically, and is expected to climb as high as 60 miles. It can crawl through the air like a snail, or go faster than a jet. Nobody yet knows its speed limit.

After a while, I closed my mouth. But David Yorysh, one of the project engineers, noticed my puzzlement.

"Any questions?" he grinned.

"Yes. What holds it up?"

"Ions," said Yorysh, as he launched

into an explanation of a wholly new flight concept.

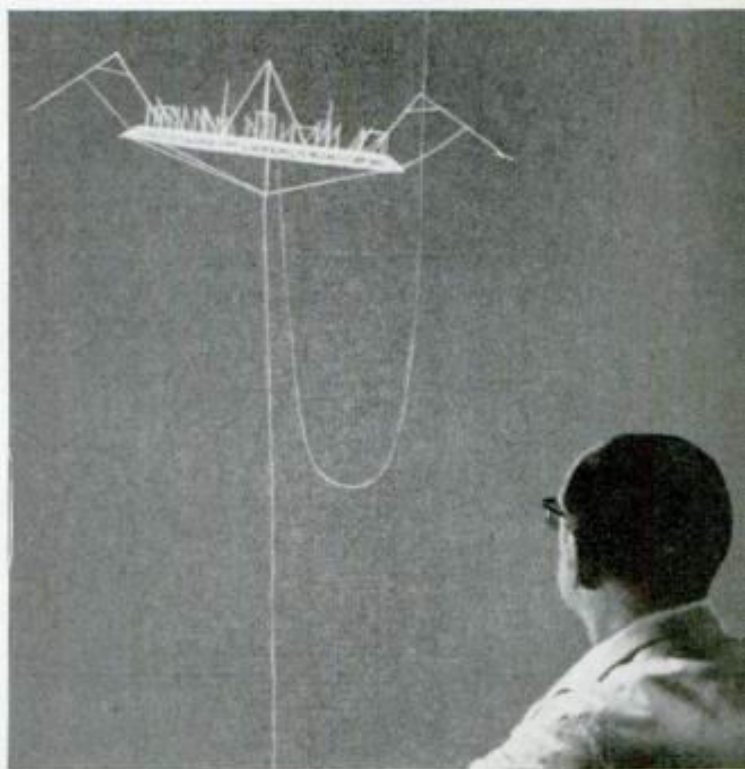
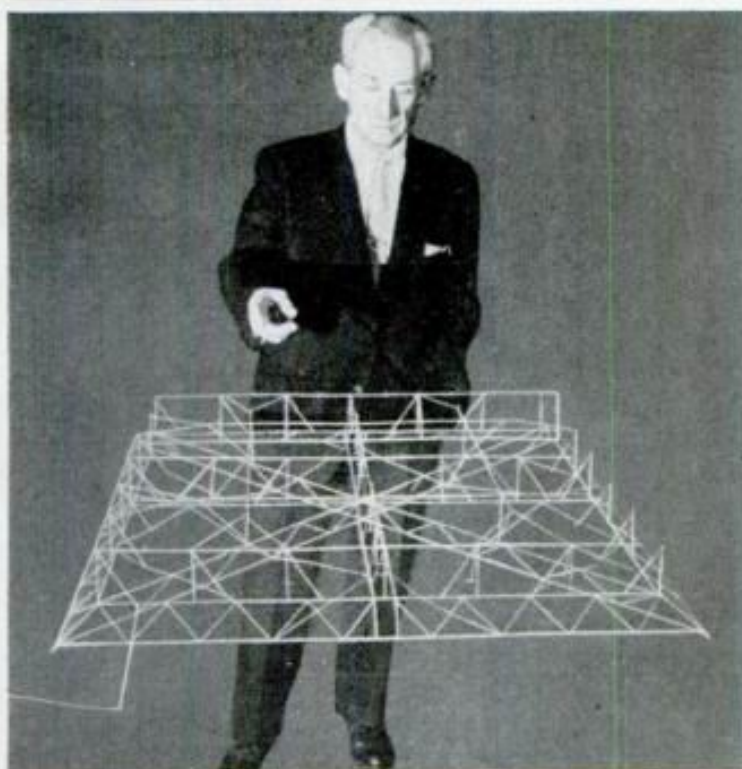
The magic carpet, called the Ionocraft, flies on pure electricity. It depends specifically on the fundamental principle of electricity that electric current always flows from negative to positive, and it uses two basic pieces of equipment to take advantage of this principle — tall metal spikes that are installed above an open wire-mesh grid. High negative voltage is shot from the spikes toward the positively charged wire grid, just like the negative and positive poles on an ordinary battery. As the negative charge leaves the spike arms, it peppers the surrounding air like buckshot, putting a negative charge on some of the air particles. Such negatively charged air particles are called ions, and these are attracted downward by the positively charged grid.

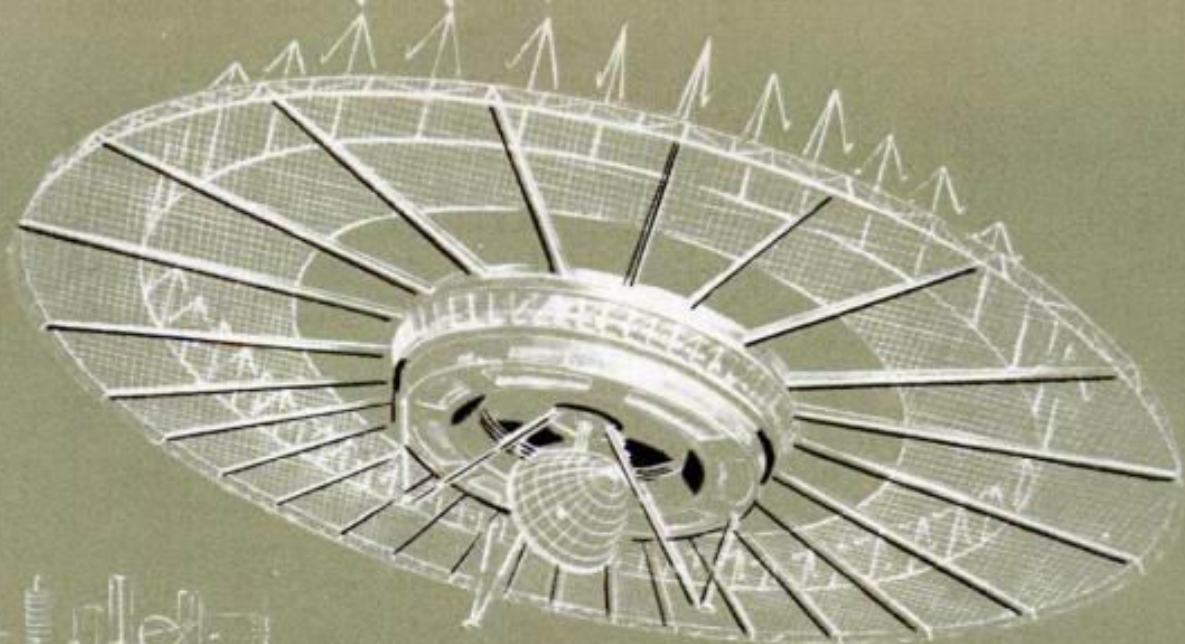
"Okay," I said. "But I still don't see what holds it up."

"I'm getting to that," Yorysh assured me as he spelled out the rest of the Ionocraft principle. In their mad rush from the ion emitter to the main

MAJOR DE SEVERSKY became interested in ion propulsion when he noticed air flow between two electrodes while working on another of his inventions

IONOCRAFT MODEL takes to air, completely unsupported except for downwash of air. Next step is to develop model that can carry its own power supply





IONOCRAFT COMMUTER may be solution for suburbanites of the future in congested areas, speeding hundreds of them short distances over heavy city traffic. Power would be supplied by chain of ground-based maser stations

grid, the ions bump into neutral air molecules—air particles without electric charge. The terrific wallop in these collisions hurls a mass of neutral air downward along with the ions. When they reach the main grid, the ions, being negative, are trapped by the positive charge on the grid. But the grid has no attraction for the neutral air particles that got bumped along. So the air flows right through the open grid mesh, making a downdraft beneath the ionocraft. The contraption rides on this shaft of air, getting its lift just like a helicopter—by sucking air down from the top.

"Aerodynamically, it works just like a chopper," Yorysh summed it up. "But instead of using a rotor and blades, we create the downward airflow electrically by means of an ionic discharge. The ions act on the air like a man treading water. They just push down."

The engineers working on the Ionocraft are the first to admit that their present rig is still a long way from any kind of practical aircraft. The model we saw measures only 1296 square inches and consists of about \$5 worth of balsa wood and aluminum wire. But the principle holds an important promise for the future of aviation.

The problem now is improving efficiency—getting enough lift from a given grid area and a given amount of energy. Present models cannot yet lift their own electric generators. They get power through a

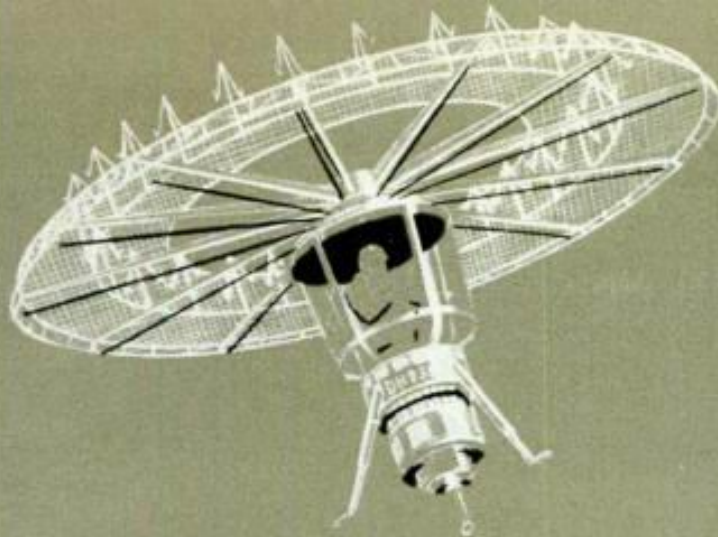
feeder cable, dangling down like an umbilical cord. Ionocraft engineers tend to be close-mouthed on performance figures. But they will tell you that at present it takes 90 watts (30,000 volts at 3 milliamperes) to fly a two-ounce model. Translated into ordinary power-to-weight ratios, this works out to roughly .96 hp. per pound, as compared with a typical .1 hp. per pound of helicopter or .065 hp. for a pound of Piper Cub.

But Ionocraft designers are hard at work upping efficiency. One possible power-boosting technique is to pulse the power in short high-energy bursts rather than to apply steady voltage. They are also trying out various grid patterns and ion-emitter layouts to minimize energy loss through turbulence in the downdraft.

Despite such unresolved problems, the development crew almost bristles with optimism, and the most optimistic of all is the Ionocraft's inventor, Major Alexander P. de Seversky. No crackpot, Major de Seversky is a practical visionary who in many areas has been far in front of his field.

"We hope to fly a model with self-contained power, perhaps by the end of the year," he told me, confidently. "Ultimately, the ionic drive will prove more efficient than either propeller or jet as a method of aircraft propulsion.

"It will achieve lift at less expenditure of energy and fuel than any other existing



ONE-MAN IONOCRAFT could be tomorrow's traffic patrol car or, in combat, hovering vehicle for guerrilla wars, all but impervious to some minor grid damage

form of aircraft. In fact, it will prove the most efficient method of converting electricity into motion."

Coming from a man of de Seversky's background, such a statement has an almost prophetic ring. A leading aircraft designer and ace flyer for the past 50 years, de Seversky's ideas have often been ahead of their time—sometimes to the embarrassment of other aviation experts. Losing his right leg during his first flying mission in World War I didn't deter him from downing 13 enemy aircraft in later flights. After coming to the United States from his native Russia, de Seversky developed bombsights and course computers during the 1920s that were the forerunners of today's inertial guidance systems.

Worked with Billy Mitchell

Later he pioneered the design of the cantilever-skin stressed wing that is now in general use. He was a consultant to General Billy Mitchell in the historic airplane-versus-battleship tactical experiments of the 1920s, and as a special consultant to the U.S. Chiefs of Staff helped formulate basic concepts of air strategy in World War II. He also contributed to the designs of the P-35 and P-43 which led to the development of the P-47 Thunderbolt, one of America's most effective wartime fighter planes. Now a trim and sprightly man of 70, he still likes to take out experimental jet planes for a spin.

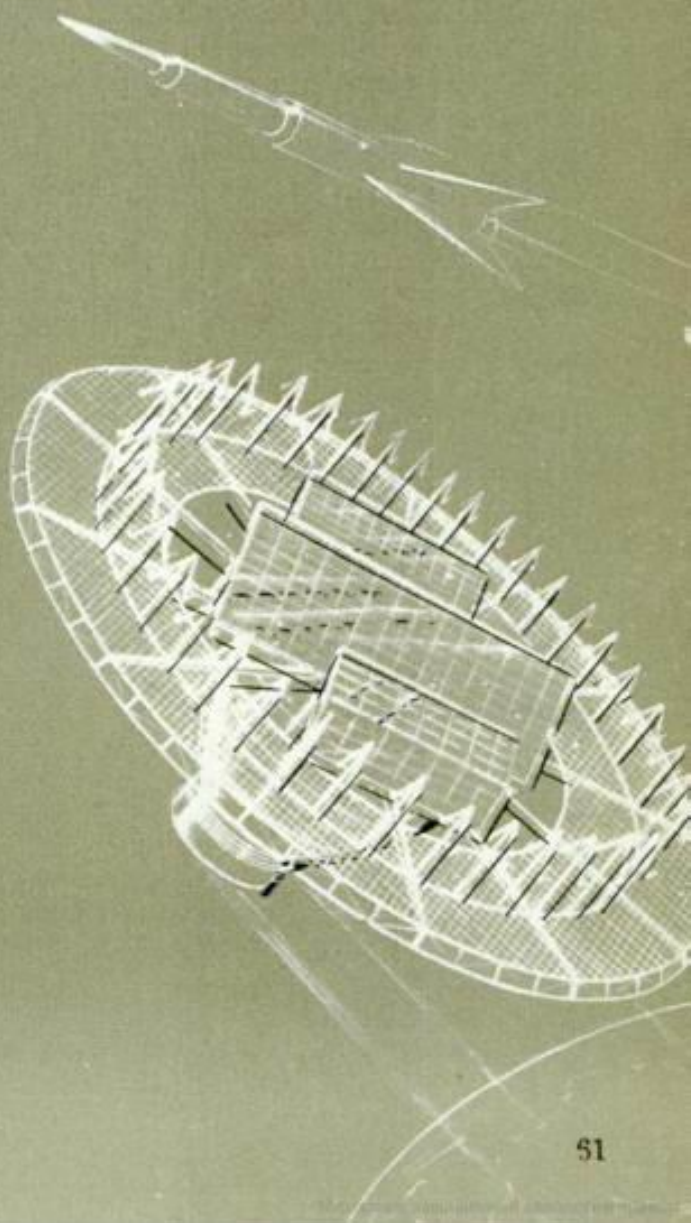
"The idea hit me as I was working on an electrostatic air-cleaning device which I had invented," the major recalled. "That gadget was designed to fight air pollution by electrically charging the particles in industrial smoke and then trapping them on a liquid electrode with the opposite charge." De Seversky noticed an air flow developing between the two electrodes, caused by the ionization process previously explained. "To an old flyer like me," said the major, "anything that stirs up a wind is a flying machine. So I began to develop the idea."

The major seemed concerned that the Ionocraft might be mistaken for a kind of space vehicle.

"This is not a spacecraft," he explained emphatically to forestall any possible misunderstanding. "It's an airplane, designed to operate within the atmosphere. But it

(Please turn to page 194)

ANTI-MISSILE IONOCRAFT, powered by sunlight, could hover indefinitely in upper atmosphere, then home in on incoming warhead and blast it out of sky



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Beyond the bullet: Japan's new train shoots for more speed

Aiming for 300 mph, engineers found a way to beat friction: Don't let the train touch the track.

by Akihiro Sato



Shot from the past: Bullet began runs in 1960s.

Back in the early 1960s, before the bullet trains began flashing between Tokyo and Osaka at more than 100 miles an hour, technical specialists at the government-run Japanese National Railways (JNR) huddled often at their imposing headquarters in Tokyo. What they discussed and dreamed about was nothing less than a total revolution in the history of land transportation: Running trains at a speed of more than 300 miles an hour, with no noise, no vibration. Thousands of hours of study and tens of millions of dollars later, JNR officials are now turning their dream into reality.

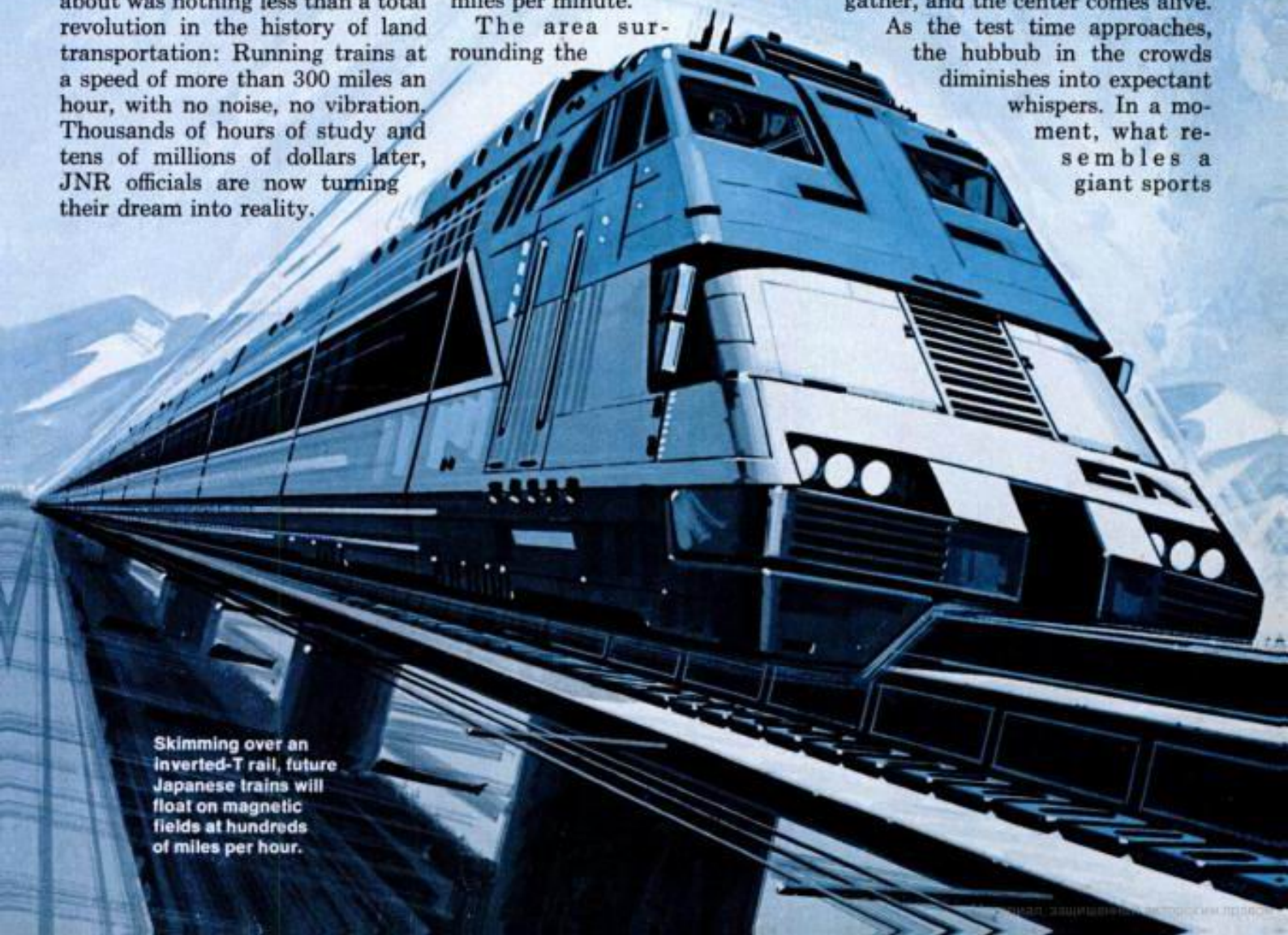
The place where the future of rail transportation is unfolding at a dramatic pace is a small town near Miyazaki, about 570 miles southwest of Tokyo. There, JNR has built a test center and has been experimenting with the prototype of a train that floats on a magnetic field and flies along a track at 5 miles per minute.

The area surrounding the

test site is idyllic. The warm air is filled with the sharp scent of pine trees. The quiet is broken only by the sound of the surf stroking the white, sandy beaches beyond the pine grove. There are usually few observers around. On test days, however, knots of people—JNR officials, technicians and visitors—gather, and the center comes alive.

As the test time approaches, the hubbub in the crowds diminishes into expectant whispers. In a moment, what resembles a giant sports

Skimming over an inverted-T rail, future Japanese trains will float on magnetic fields at hundreds of miles per hour.



car floats into view on an elevated four-mile track, and zips by in a whirl of wind, with a low-pitched whine.

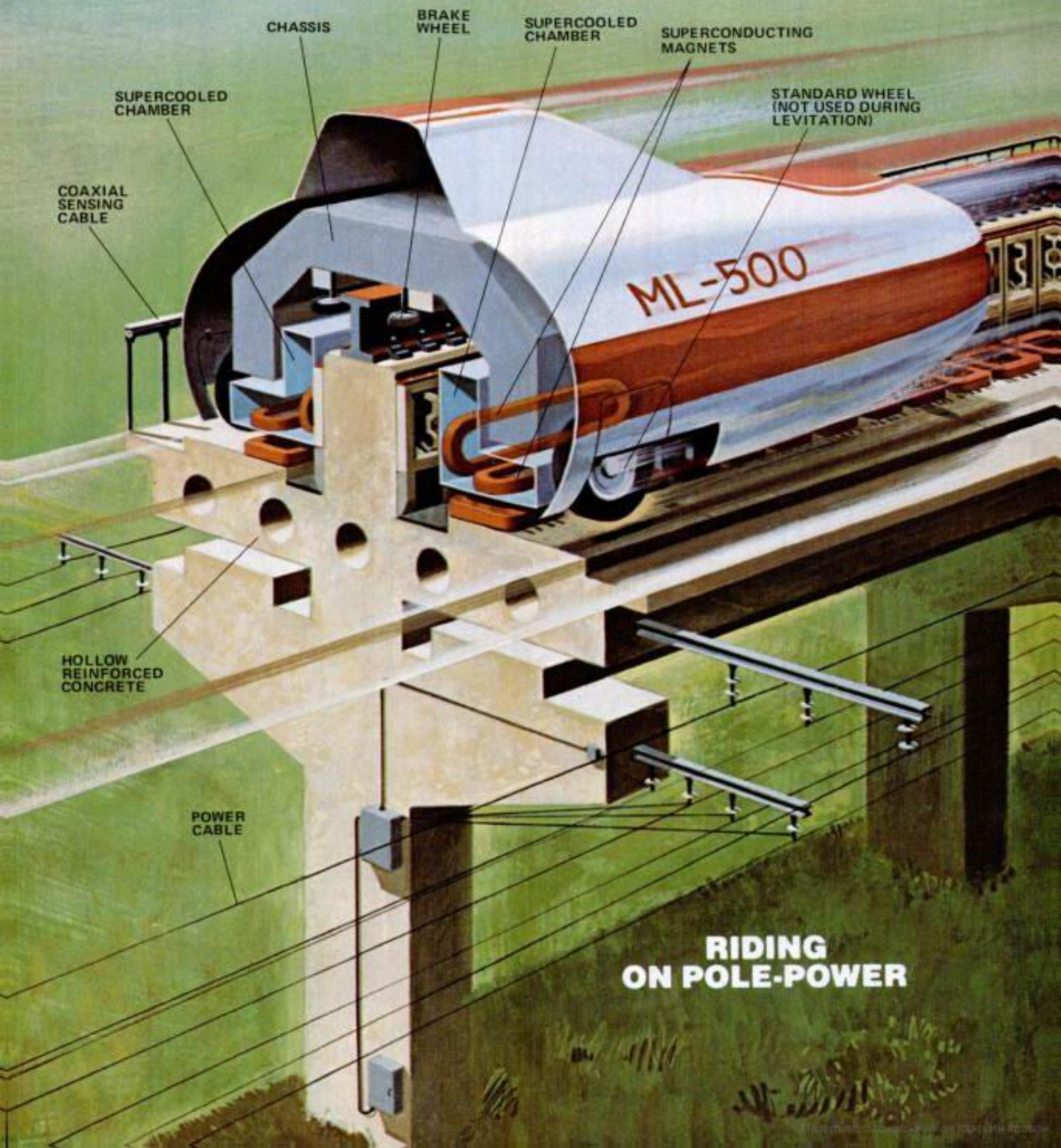
The experimental 44-foot-long car, creamy white with a bold streak of red across its sleek body, leaps forward over a single track. The colors blur as it passes, buoyed up by the repulsive force of a magnetic field. In an instant, it's gone.

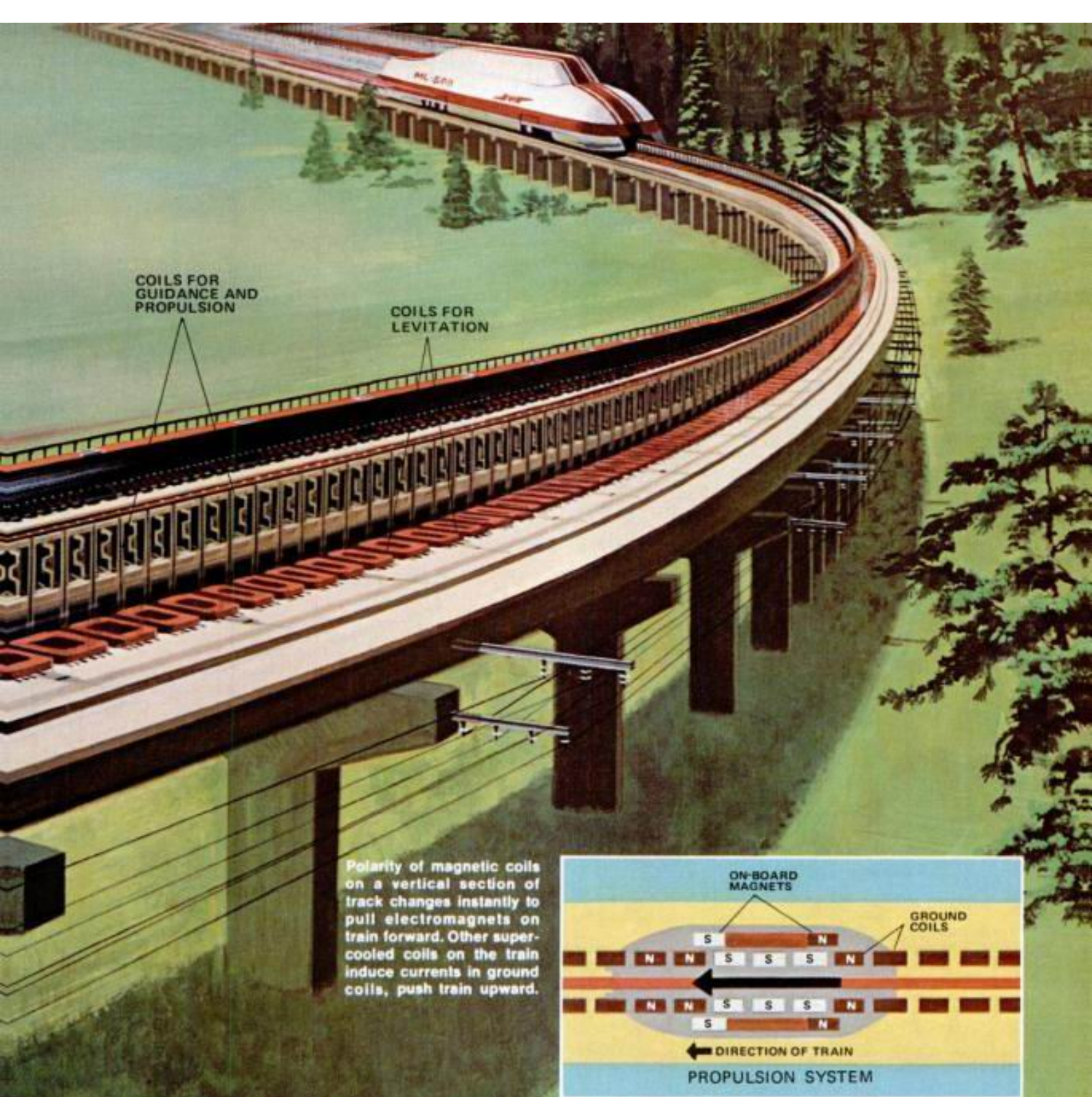
When its "bullet" trains went into service in 1964, JNR officials boasted that they were so quiet and smooth that a pencil left standing on a seat table wouldn't topple—a claim that has since been proved more than a little exaggerated. More than a few cups of coffee were spilled as the trains thundered along the rails. This time, however, officials say a pencil

really won't fall and passengers can enjoy a cup of coffee or glass of wine filled to the brim without worrying about spills. Thousands of magnets, they say, will cushion the ride.

As simple as a toy, but . . .

The magnetic system that's raising JNR's prototype train—and hopes—is as simple in principle as





JNR technicians pump liquid helium in prototype's four chambers. Supercooled coils inside hold strong magnetic force during run.

Near start of test on Miyazaki track, 10-ton train rises 4 to 5 inches. Note shadow under wheel. Prototype has hit 320 mph.



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AVIATION

Airport ahoy!

The *Nimitz* was never like this. The floating airport you see below would offer its passengers duty-free shops, banks and travel agencies, a movie theater, bar—and a 1953-foot runway capable of handling four-engined, 50-seat planes.

If Seaforth Maritime Ltd. of Scotland wins the financial backing it needs to develop the \$165 million craft, it could brighten gray, blustery winters for North Sea oil-platform workers. It could also cut costs of 470,000 yearly passenger transports.

Currently, the flow of men to and from North Sea rigs is anything but smooth. To get to work, crews take off from Aberdeen, Scotland, then transfer to helicopter up north in frequently foggy Sumburgh for a noisy, slow trip out to sea. Floating on pontoons, the Seaforth Stolport would accommodate the De Havilland Dash 7 short takeoff and landing (STOL) aircraft, which

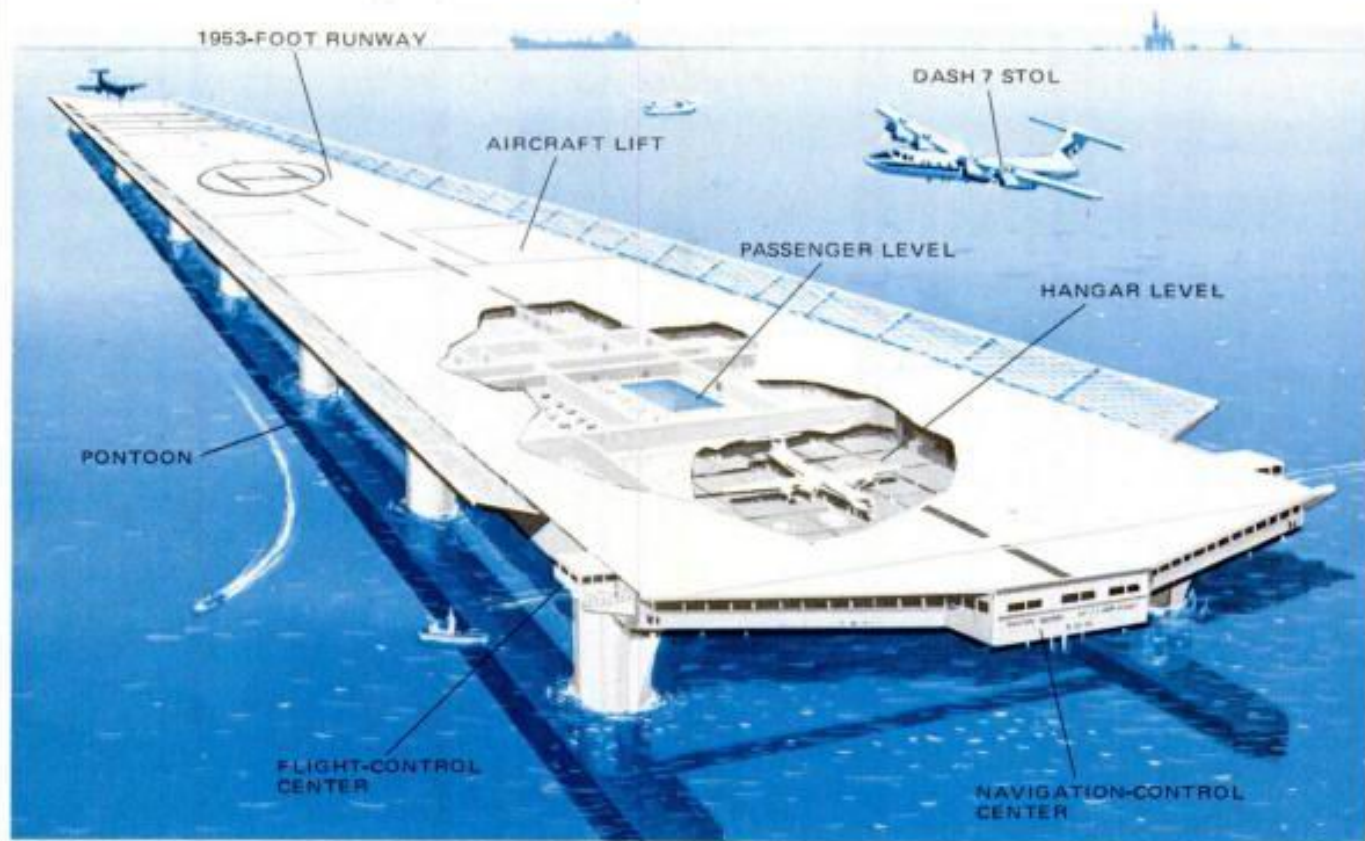


Fly-casting takes on a new dimension in the Humbug ultralight with Styrofoam floats (from \$4400 from Sky Sports Inc., Ellington, Conn. 06029). The 120-pound craft, with a 35-foot wingspan, takes off at about 20 mph.

could fly to the carrier near the rigs. There, men would transfer for a short helicopter trip.

Plans for the stolport, almost twice as long as the U.S. Navy's *Nimitz* carrier (1092 feet), call for two levels under the runway. The lower level would house aircraft.

Upper-level living areas would include a hospital with facilities to treat divers. "You could build in whatever you wanted," a Seaforth spokesman told us. "Sports arenas. Hotels. You could house wives there, and workers could commute to the rigs." **PM**



Three-level floating airport would serve 17 oil rigs, with space for recreation, banks, a hospital, shops and hangars.

ENERGY

Westinghouse's wand

Westinghouse Electric Corp. is about to begin large-scale testing of a process that uses a kind of wand to pull solar cells out of a vat.

Westinghouse developed the technique for the space program, and revived it during the energy crisis. It's comparable to dipping a child's bubble wand into soapy water, and withdrawing a chain of bubbles.

In the complex Westinghouse equipment, the "wand" is a tiny filament dipped into silicon at 2650° F. A bead forms at the tip of the filament. Two small posts sprout out of the bead. As the filament is extracted, the silicon forms a web between the posts. At a rate of nearly 6 feet an hour, the web cools to a smooth, single-crystal ribbon, later cut into strips.

Silicon strips are the heart of photovoltaic cells that absorb energy from the sun to produce electricity.

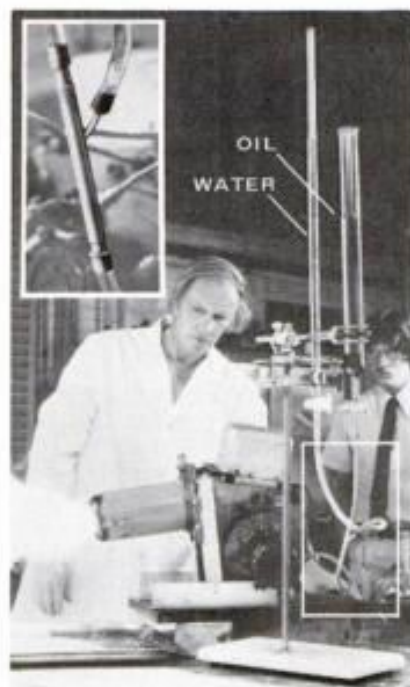
Pacific Gas & Electric Co. and Southern California Edison recently committed \$300,000 each toward the operating costs of a 50-kilowatt-per-year pilot facility to be built by Westinghouse. By 1986, a larger, fully automated plant should be turning out cells at a cost of 70 cents a peak watt. Costs currently range from \$7 to \$22 a peak watt.

Watered-down fuel bill

A Bayville, N.Y., inventor reports cutting his fuel bill 14 percent by using a process which adds water to the oil his furnace burns.

Inventor Eric C. Cottell, who holds patents on methods to keep cold cream and suntan lotion from separating, began research on energy-related devices decades ago.

During the critical oil shortage induced by the Suez crisis of 1956, he powered his motorbike with an oil-water mixture. Today, Cottell has used this expertise in emulsions—suspensions of one liquid within another—to mix water and oil into a milky-orange fuel which, he says, saves



Cottell uses "emulsion integrator" (inset) to mix water, heating oil.

money and also cuts pollution.

An install-it-yourself kit, he says, should retail for \$30 and could be on the market in six months. The market appearance of the process, however, depends on when Cottell finds a manufacturer. (He has designed a similar device for diesel engines that is not yet on the market, either.)

The main component in the kit is an "emulsion integrator," which premixes the oil and

water. Operating on just the water-oil pressure, it consists of a series of propellers rotating in opposite directions. The emulsion flows into the burner's high-pressure pump. Minute water droplets disperse within oil drops. As the atomized emulsion is shot out the pump nozzle, the water particles explode at about 270° C., ripping the oil droplet apart.

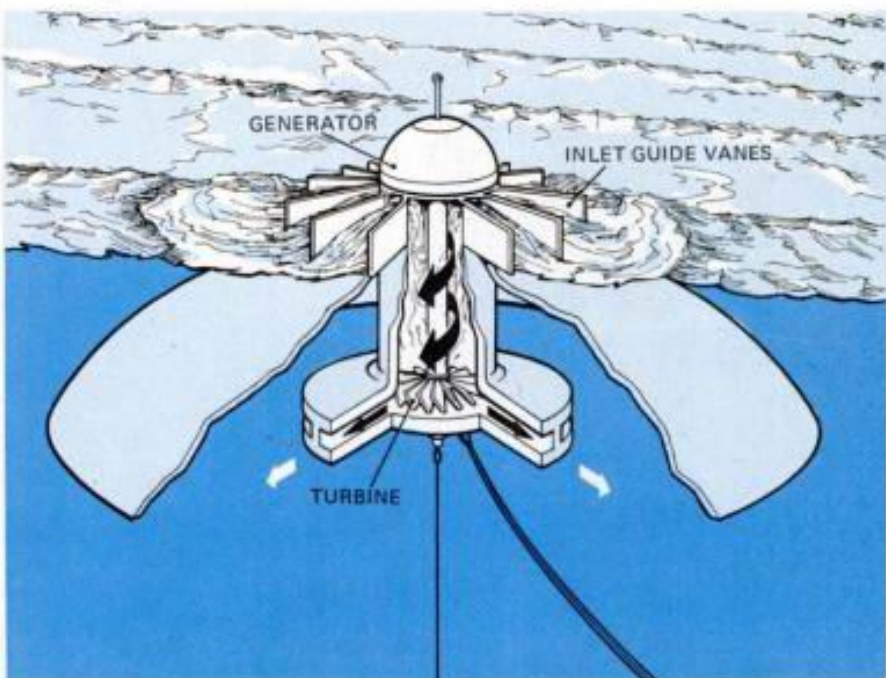
Home-furnace emulsion systems have not always fared well in controlled tests. Brookhaven National Labs in Upton, N.Y., reported that one system it tested in 1977 used extra oil to heat the water, decreasing efficiency. Cottell maintains that the high-temperature explosion of water droplets in his patent-pending system will give the homeowner a longer time between oil deliveries and a short payback period.

Watts from waves

The artificial atoll (below) draws energy from ocean waves to generate electrical power.

Lockheed Missiles & Space Co. is developing the "Dam-Atoll," a moored, 280-foot-diameter dome arching over a cylindrical central core.

As a wave slows its speed when it hits the outer lip of the dome, the water bends or refracts. Vanes guide the curving water into the core where a whirling vortex turns a turbine. **PM**



Like light entering a new medium, waves bend when they hit shoal.

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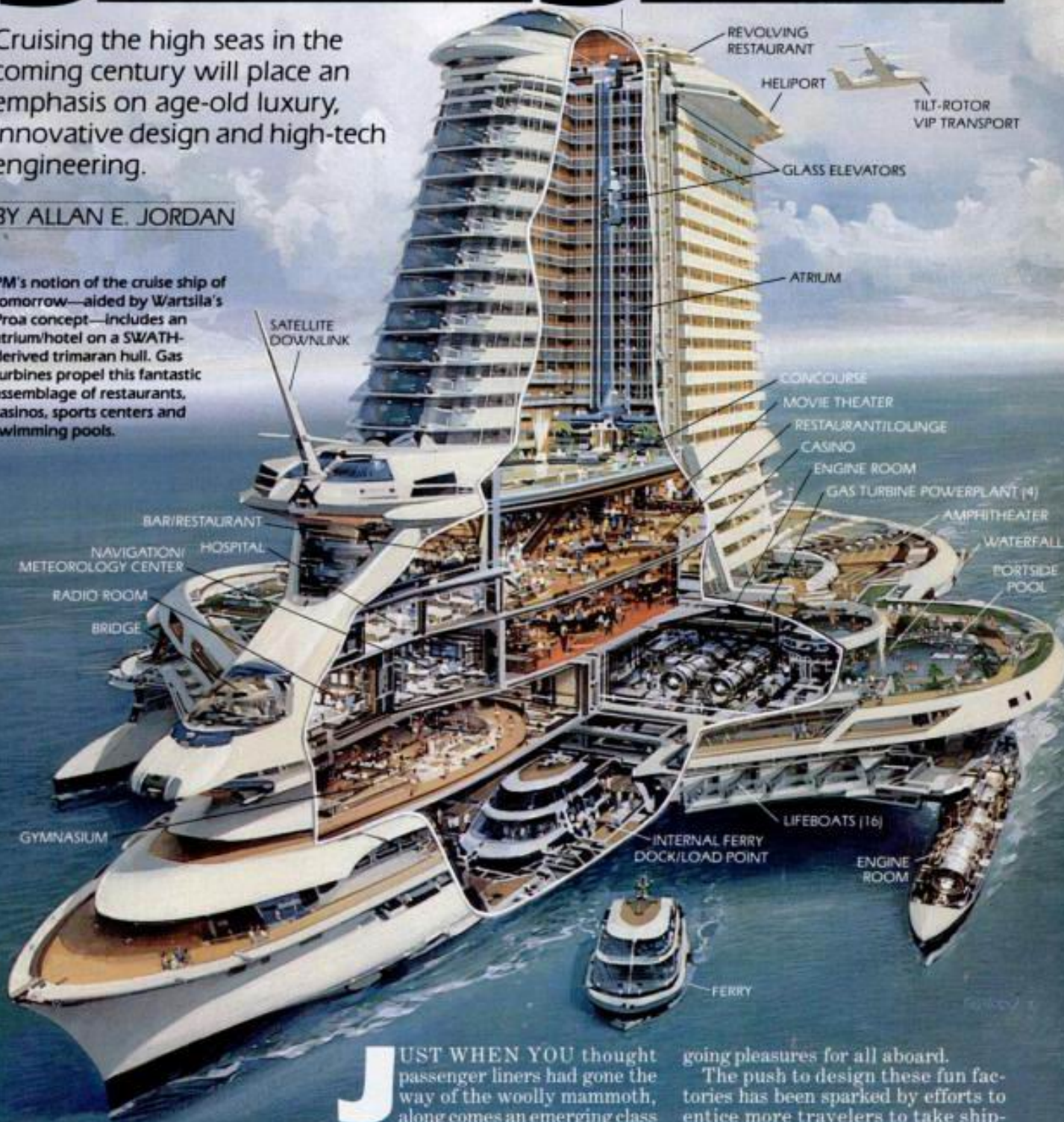


SUPERSHIPS

Cruising the high seas in the coming century will place an emphasis on age-old luxury, innovative design and high-tech engineering.

BY ALLAN E. JORDAN

PM's notion of the cruise ship of tomorrow—aided by Wärtsilä's Proa concept—includes an atrium/hotel on a SWATH-derived trimaran hull. Gas turbines propel this fantastic assemblage of restaurants, casinos, sports centers and swimming pools.



JUST WHEN YOU thought passenger liners had gone the way of the woolly mammoth, along comes an emerging class of cruise ships designed to titillate even the most jaded Sybarite. Far surpassing the passenger vessels that once plied global sea lanes, these new cruise ships will be destinations unto themselves, floating Xanadus that will offer an invigorating mix of sea-

going pleasures for all aboard.

The push to design these fun factories has been sparked by efforts to entice more travelers to take ship-board vacations. The quest is leading the \$4 billion cruise industry through an evolutionary growth period that may one day spawn a generation of innovative vessels twice the size of today's largest ships.

Right now, passenger shipping's

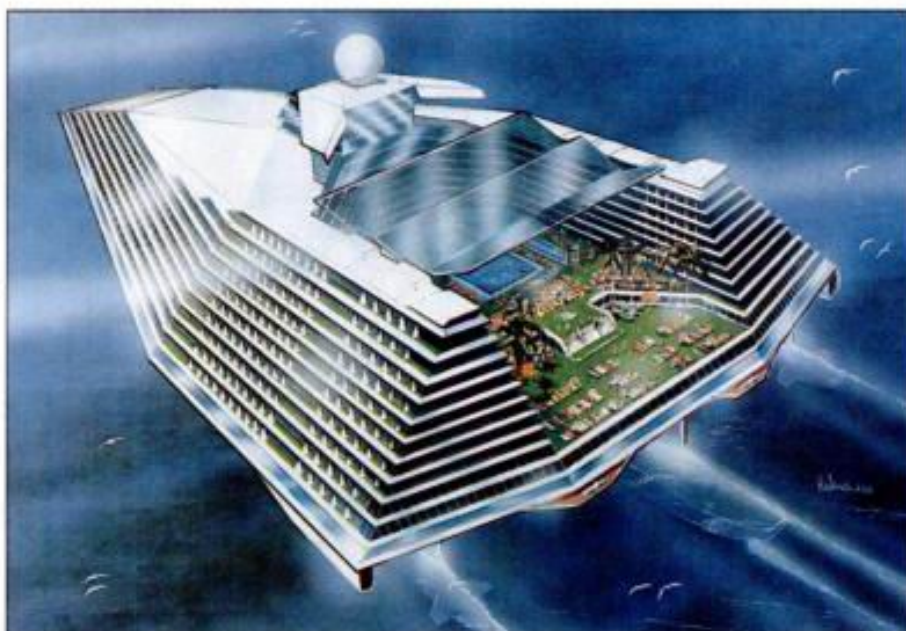
SUPERSHIPS

standard bearer is Royal Caribbean Cruise Lines' *Sovereign of the Seas*. At 74,000 gross tons, *Sovereign* is the largest cruise ship ever built, and her 2282 passengers are surrounded by unrivaled luxuries—including a 5-deck interior atrium with two glass elevators, and a 275-seat lounge cantilevered 12 stories above sea level.

In the continuing progression of cruise-ship design, experts predict super cruise ships like *Sovereign* will become the stepping stones to the megaships of the 21st century. This next generation will not only be two to three times larger, but will introduce tennis courts, beaches and in-hull harbors as they strive to become the vacation dream of millions.

Phoenix—A foretaste

The inspiration for these 21st century megaships may come from *Phoenix World City*. A consortium of German shipbuilders has completed initial agreements and design studies to create this 5600-passenger cruise ship of tomorrow. *World City* will be more than three times the size of *Sovereign of the Seas* and will incorporate a split stern that will shelter a harbor where four 400-passenger day cruisers/tenders can dock. *Phoenix World City*'s hotel areas are located in three



A trimaran SWATH concept permits additional space amidships for recreation.

8-story buildings atop her 1243-ft. semicatamaran hull. Designers anticipate tropical gardens, parks, promenades, cafés and a 4-pool lagoon with palm trees and a real sand beach.

Cutting a SWATH

Hull design has a direct bearing on passenger comfort, particularly in

heavy seas, and designers looking beyond *World City* see great promise in the SWATH design (Small Waterplane Area Twin Hull).

Swift and ultrastable, SWATH is a platform lifted above the water by struts which are attached to two submerged pontoons that provide the vessel's buoyancy. The struts define the ship's "small waterplane area." Whereas conventional ships ride the waves, this strut and pontoon concept permits the SWATH to safely manage surface turbulence.

Moreover, large cruise ships have length-to-width ratios of between 6:1 and 7:1, a SWATH vessel's ratio is approximately 2.5:1. This feature makes the SWATH well suited to be a cruising holiday center, according to officials at Finland's pioneering shipbuilder, Wartsila Marine. Wartsila, which has built more than a dozen leading cruise ships, has developed the SWATH 2000 Cruise Liner, a 500-ft.-long, 200-ft.-wide vessel to accommodate a minimum of 2000 people.

Key feature of SWATH 2000 is a large 30,000-plus-sq.-ft. central recreation area, derived from the wide beam. This outdoor court would be sheltered on three sides by 1000 passenger cabins, many of which would have private balconies facing either the ocean or recreation area. Within the recreation area would be cafés, gardens, a large swimming pool, a surfing beach, squash courts, even escalators and a water slide. Also envisioned are underwater and celestial observatories.

While SWATH matures on the drawing board, it has also served as the starting point for other future



Extending the principal, future SWATHs might include separate deployable harbors.

cruise-ship designs. One such design, the Wartsila-developed *Proa*, is a ship whose main weight is placed on a central hull. A smaller side pontoon supplies SWATH-like stability.

Tricruiser employs two side pontoons to form a triple hull. The passenger facilities are contained in a high-rise building located on a platform deck surrounded by a beach area complete with palm trees.

Big MACS

While many future designs are emerging from Europe, Japan's famed industrial companies are also seeking to establish themselves as builders of large passenger ships. One such organization is Nippon Kokan KK (NKK), which has joined with leading Norwegian architects to produce a concept called MACS (Multi Activity Cruise Ship).

The 3000-passenger MACS are based on a wide-beam hull: 853 ft. long with a 141-ft. waterline beam that expands to 177 ft. at the superstructure. She would include a split stern for an internal harbor similar to that of *World City* and *Tricruiser*.

Future prospects

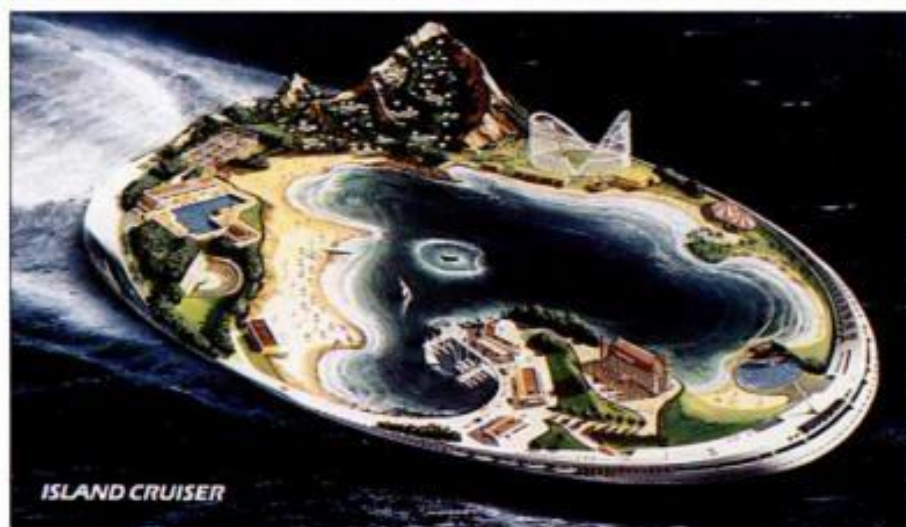
In the near future, no less than a dozen new ships are due to be introduced, including five 70,000-gross-ton super cruise ships. These vessels will continue the competition to introduce features ranging from expanded recreational facilities to glass-domed observatories and taller atriums.

If one wonders where all this is heading, France's leading shipbuilder, Chantiers de l'Atlantique, functioning at the mouth of the Loire River for more than 100 years, may have designed the ultimate cruise experience with its island cruiser.

At first glance, the large circular ship might appear to be strictly fantasy, but closer observation reveals a vessel not all that different than the megaships. On the island's platform deck is a lagoon surrounded by hotels, beaches, marinas, tennis courts, landscaped gardens and an amusement park. The design includes lifeboats suspended below the platform deck.

While this design may seem unobtainable, one must remember that the evolution to the 74,000-gross-ton *Sovereign* from the 1960's cruise ship—a 18,000-gross-ton, 700-passenger vessel—was made possible by a quadrupling of consumer demand for cruises in the past two decades. As this passenger growth continues unabated, the leap to these megaships is just another step in an ever-expanding marketplace.

The Shape Of Ships To Come



Royal Caribbean Cruise Lines' *Sovereign of the Seas*—nearly twice the size of today's contemporary cruise ships—has started a design revolution that may result in *Phoenix World City*, the SWATH-influenced *Tricruiser* and Chantiers de l'Atlantique's fantasy ship, *Island Cruiser*, a motorized atoll that sports a roller coaster.

ROYAL CARIBBEAN CRUISE LINES PHOTO

ALLAN JORDAN PHOTO

WARTSILA ILLUSTRATION

CHANTIERS DE L'ATLANTIQUE ILLUSTRATION

NASA's Performance Engine

PASADENA, CA—Fuel efficiency is becoming a major consideration as NASA pushes for an ambitious planetary exploration agenda.

At the space agency's Jet Propulsion Laboratory and Lewis Research Center, researchers are testing a new high-performance rocket combustion chamber made of the rare metal rhenium.

Conventional rocket chambers are forged from

stainless steel. During combustion, some of the propellant is wasted because it lines the inner wall of the chamber to prevent the steel from melting in an effect known as film cooling.

But rhenium, with its much higher melting point, will support more complete combustion. In conjunction with the program, NASA contractors have developed a propellant injector that

sprays fuel into the center of the chamber, to decrease unnecessary film cooling.

One drawback: hot rhenium is prone to oxidation. To prevent that corrosion, researchers plan to use chemical vapor deposition to line the chamber with another rare metal, iridium, which resists oxidation. The materials will allow engineers to stick with existing engine technology while increasing spacecraft payloads.



Red-hot rhenium chamber torture-tested in vacuum chamber.

Tracking Train Tech

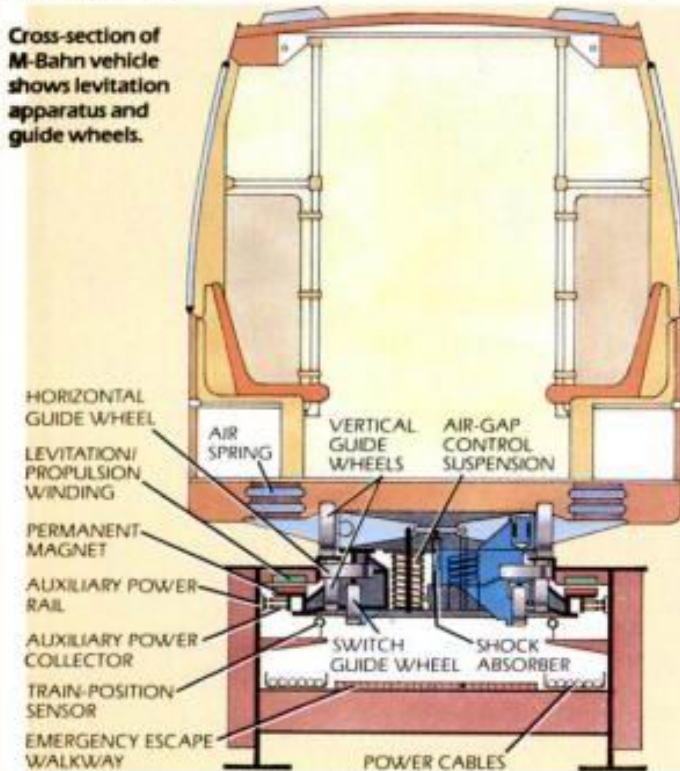
NEW YORK, NY—Faced with a future of gridlocked traffic, local planners are paying increased attention to new rail technologies to relieve road congestion.

One near-term solution might be M-Bahn, a low-speed magnetic-levitation system now operational in West Berlin. Unlike high-speed experimental maglevs (see "Supertrain," page 78, June '88), the M-Bahn vehicle doesn't break contact with a guideway. Magnetic lift simply takes the load off a system of guide wheels.



Flight Train roars along highway median strip.

Cross-section of M-Bahn vehicle shows levitation apparatus and guide wheels.



Lift is provided by the attraction between magnets on the undercarriage and two electrically charged windings. Current traveling through the same windings provides propulsion.

The guide wheels keep the train on track and also hold the magnet-to-winding air gap constant. A large spring also stabilizes the air gap by compensating for variable passenger load.

Interestingly, the on-board magnets aren't the electromagnets of other systems, but permanent magnets. Benefits of using permanent magnets include reduced energy consumption and maintenance of levitation in case of power failure.

Developed by the West German industrial colossus AEG, M-Bahn will make its U.S. debut in Las Vegas,

shuttling passengers between the convention center and a downtown location.

Meanwhile, a South Florida inventor has patented a different breed of levitating locomotive.

Known as the Flight Train, George Bell's invention relies on a series of stubby wings on the roof of each car to provide aerodynamic lift. Tracks run along all sides of the train, which carries magnetic sensors that move through grooves in each track. Retractable wheels deploy at low speeds or in emergencies. The sensors pick up any deviation in movement and feed data to a central computer, which then controls flaps on wings to keep the train steady. Reaction-control thrusters also supply corrective forces. Power is provided by a rear-mounted jet engine.

HELIPORT 2000

It's been 50 years since Igor Sikorsky perfected vertical-lift aircraft. The next 50 will see dramatic improvements in helicopter power, control and avionics.

BY FRED MACKERODT, Contributing Editor
PM Illustration by John Berkey



NEW YORK, NY, 2020 — Back in the old days, before most major cities on the East Coast constructed waterside vertiports to speed intercity travel, flight time from Washington, D.C., to Manhattan took nearly 3 hours. About 45 minutes of that was actual flight time. The rest was travel to and from airports. Congested ground transportation and near total gridlock in our nation's air traffic control system cost travelers precious time and lost productivity.

But today, we've cut the trip to about an hour. And if you'll lean back in your ergonomically correct passenger chaise and look out the starboard side viewport of this new Sikorsky Very Large Civil Transport helicopter, you and 99 fellow passengers will see what created the enormous efficiencies of modern air travel.

We're about to land on that collection of landing pads and passenger terminals jutting into the East River — anchored safely to crowded Manhattan by passenger walkways and

auto ramps, its over-water approach pattern permitting safe, noise-reduced maneuvering for our helicopter, one of the world's largest.

The VLCT's trailing-arm main gear extends and we delicately alight. A Bell-Boeing civil tiltrotor on an adjacent flight pad advances power and sails skyward. Passengers stream to rail, auto and ground-effect craft water links. Outbound ticketholders queue for the trip back to D.C. The system, created in the throbbing heart of downtown New York, speeds people and commerce in the wheel and thunder of a nation abuilding.

We owe this effort-free travel network to the city planners of the 1990s. Back then, they decided that movement between population centers could best be achieved through an infrastructure designed to take advantage of emerging techniques for taking off and landing aircraft vertically. VTOL eliminated the need for commuter airlines that consumed landing slots best-suited to long-distance

The vertiport of tomorrow might include landing pads for both tiltrotor transports, designed for medium-distance travel, and Sikorsky's Very Large Civil Transport. Constructed adjacent to open waterways, future heliports would permit safe maneuvering while respecting noise-abatement laws. Merging infrastructure with vertical takeoff and landing technologies will relieve air traffic congestion, expected to worsen as the next century unfolds.

haulers, liberating the nation's beleaguered air traffic control system. Bringing the airport to the passengers also reduced traffic snarls and pollution.

What made it possible? The marriage of this remarkable infrastructure with technologies that were in



HELIPORT 2000

their nascent stages back in the 1980s. Tiltrotor tech was an obvious way to move people up to 600 miles. And the enormous VLCT—Sikorsky's magic carpet—linked exurban areas and nearby cities to fuel economic growth at the start of this new and exciting century.

Back to Earth

Of course, the interesting part about the foregoing fantasy is that it veers only slightly from the realm of the possible. Japan is constructing an extensive infrastructure for helicopters throughout her archipelago. The on-again, off-again tiltrotor, recently canceled by the Defense Department for budgetary reasons, has significant potential as a commercial transport. And Sikorsky's VLCT already exists—in slightly altered form.

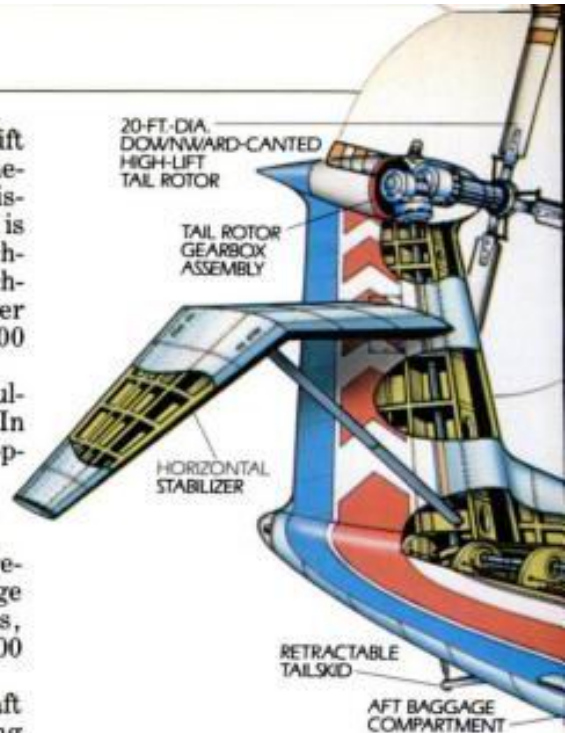
When Sikorsky Aircraft presented a drawing of its future VLCT at the Helicopter Industry Assn. meeting last January, only the drawing was futuristic. Technologically, the machine was doable with even less than state-of-the-art tooling and materials. The idea was to present a concept helicopter with passenger-hauling capabilities rivaling that of fixed-wing

commercial aircraft. The ability to lift and transport 100 passengers in a helicopter over short and medium distances at speeds more than 150 mph is simple using presently available technology. And it would only be stretching it a little to envision a helicopter capable of hauling as many as 200 passengers.

Military choppers have been hauling larger loads around for years. In fact, Sikorsky's own CH-53E helicopter now used by the Marines (*Super Stallion*) and the Navy (*Sea Dragon*) is capable of hefting loads up to 32,000 pounds. The load requirement for the VLCT, with an average passenger weighing 170 pounds, would be somewhat less than 20,000 pounds, including baggage.

The CH-53E, in fact, is the aircraft Sikorsky would use as the starting point for developing the VLCT. Like its military antecedents, the VLCT would be powered by three turbines, putting out more than 13,000 horsepower. It would also probably use a 7-blade rotor similar to that found on the present military chopper. Items like the landing gear and drivetrain would also swap over.

So if it can be done today, why

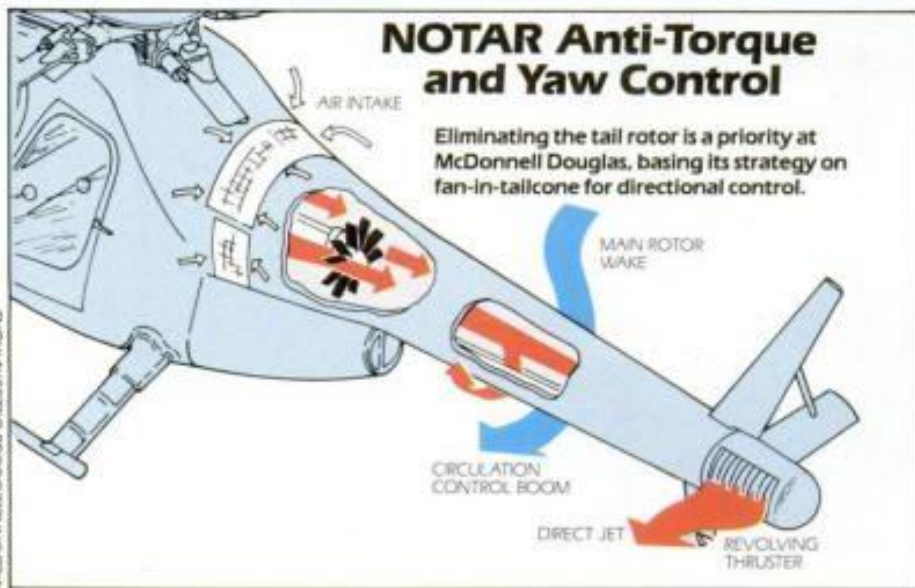


doesn't Sikorsky just go and do it? Because a lot of things have to be in place before the VLCT would be commercially feasible. First, you need the heliports for the VLCTs to fly into and out of (tiltrotor proponents prefer the term vertiports). Then, you would need a whole separate air traffic system—complete with ground navigation aids and control personnel—to get the most benefit out of vertical takeoff aircraft like the VLCT.

The present system, especially around large metropolitan areas like New York, Chicago and Los Angeles, is quickly reaching saturation. Airports are even closer to capacity. New slots are just not available, and the existing ones get gobbled up by current carriers. A lot of those slots are being used for short-haul flights, flights that would be ideal for aircraft like the VLCT.

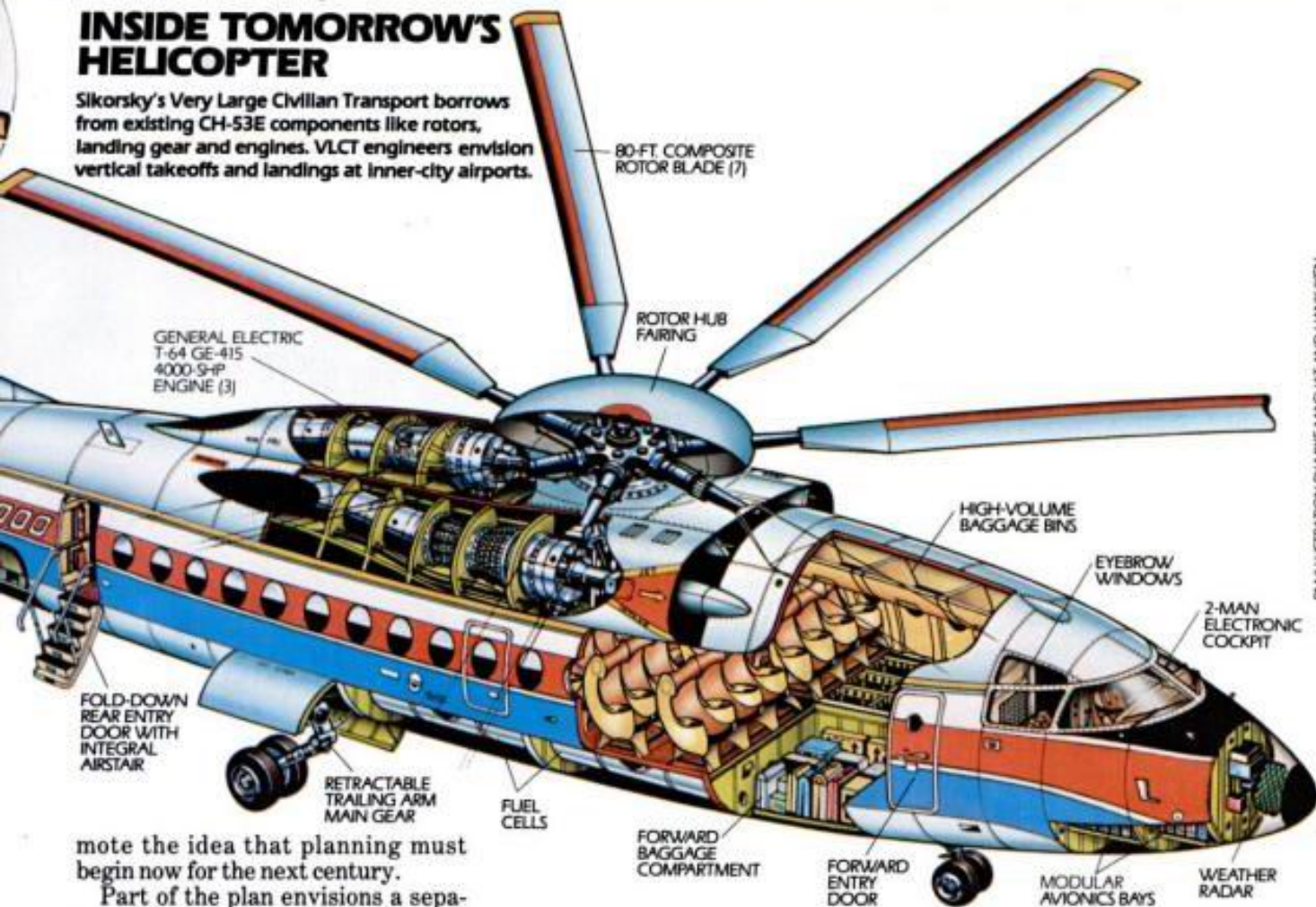
Conventional fixed-wing aircraft have reached their size limit—about 500 passengers is tops. And whether the airplane is a 747 bound for Tokyo, or a small commuter coming in from 100 miles away, only one aircraft can fit on one runway at a time. Japan has even worse problems. The country's current intercity travel system is overloaded. That is why the Japanese are looking most seriously at a proposal to build a system of 600 heliports, with the possibility of eventually having 3300 of them.

Add to this the fact that more and more people who have never flown before are climbing into commercial airplanes every day, and you have the potential for massive problems popping up around the turn of the century. A separate vertical takeoff system would be a neat solution to the air travel mess the experts forecast. In fact, that's the reason behind Sikorsky's proposal for the VLCT—to pro-



INSIDE TOMORROW'S HELICOPTER

Sikorsky's Very Large Civilian Transport borrows from existing CH-53E components like rotors, landing gear and engines. VLCT engineers envision vertical takeoffs and landings at inner-city airports.



PM ILLUSTRATION BY MIKE MACHAT AND HANK KEN

mote the idea that planning must begin now for the next century.

Part of the plan envisions a separate air traffic system just for vertical takeoff machines. Roy Lobosco, who is working on an FAA-funded study on the issue of heliports for the Port Authority of New York and New Jersey, points out that with the new system, helicopters would also be able to fly into and out of airports without conflicting with fixed-wing traffic, adding enormous versatility.

A new VTOL system, as some vertiport visionaries see it, would have aircraft like the VLCT handling trips from 100 to 200 miles. Tiltrotor aircraft, with twice the speed, would handle longer distances, say from 300 to 600 miles.

Key issues

While some may argue that future large-scale VTOL flight remains a distant dream, the basic systems we'll find aboard tomorrow's helicopters are taking shape right now. Military VTOL programs are closely linked to the advancement of civilian VTOL technology in general—technology directly transferable to the VLCT of the future.

For instance, the current program for the development of a new Army helicopter, dubbed LHX, is the main engine driving vertical flight technology at the present time. Two teams—McDonnell Douglas/Bell and

Boeing/Sikorsky—are currently competing to see who will build the \$38 billion worth of new Army helicopters LHX planners envision. This prize, which is supposed to be awarded in December 1990, represents 50 percent of the world's new helicopter

business over the next 20 years.

With a plum this huge ripe for the plucking, you can bet that the two teams are working at full steam to do their best to develop the world's best helicopter. And a lot of what's being

(Please turn to page 102)



Vertiport visionaries also see a future role for a commercial version of the Bell/Boeing V-22 Osprey tiltrotor.

PM ILLUSTRATION BY ED VAUGHSKY

SEPTEMBER 1989

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DRIVE REPORTS

VERTICAL TAKEOFF AIRLINER

Giant Helicopter Will Carry
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HOME & SHOP JOURNAL

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TRACKING A KILLER HURRICANE

Planes, Satellites
And Computers
That Save
Lives



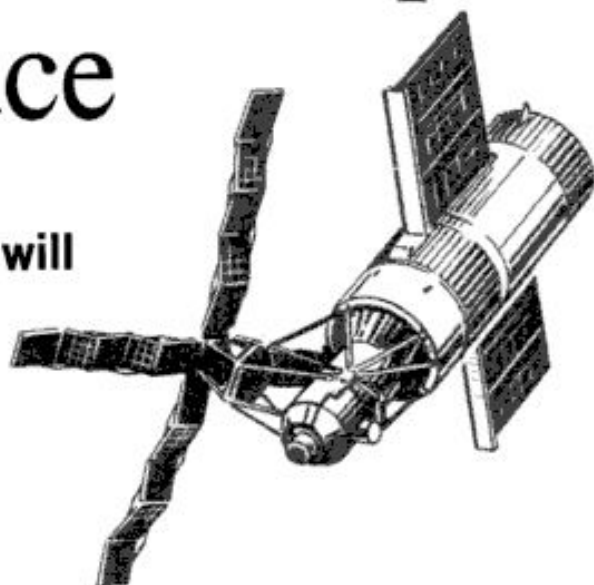
**CALIFORNIA
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SKYLAB: Our Next Giant Step In Space

Late in '72 a mighty Saturn rocket will blast a three-man workshop and lab into Earth orbit —a mission that could prove a springboard to Mars

By JOHN F. PEARSON, Science Editor



ABOUT A DAY APART, late in 1972, two towering Saturn rockets are scheduled to rumble skyward from Kennedy Space Center. A Saturn 5, with only its first two stages loaded with propellants and its empty third stage equipped as a workshop, will orbit the hardware for Skylab, America's first space habitat. A three-man crew will follow in a Saturn 1-B. Riding with them will be a big question: Can man live and work in a weightless environment for extended periods?

Apollo moon missions can't provide the answer. They're like a quick test drive around the block when you're wondering if your car will take you cross-country. The longest U.S. space mission to date was Gemini 7, in 1965. It lasted 14 days. Recently, Russian cosmonauts spent 18 days in orbit. But the question remains.

Skylab is the most extensive and elaborate mission yet dreamed up by NASA planners. The blueprint calls for three three-man crews to live successively aboard Skylab and carry out some 50 scientific experiments. They'll

aim telescopes at the sun, test themselves in various ways, try out new space devices, and use spectrometers and scanners to develop new information about the Earth. The first crew will remain in orbit up to 28 days, and the two other crews will each attempt to stay as long as 56 days. The mission will take about eight months to complete.

If Skylab goes well, it will be a giant step toward space voyages lasting months or even years. Some top NASA scientists think we'll be sending manned flights to Mars as early as the 1980s.

Skylab will orbit the Earth at a height of 270 miles. It will not be a single spacecraft but will be made up of a cluster of components: orbital workshop (OWS), airlock module (AM), multiple docking adapter (MDA), and Apollo telescope mount (ATM). The cluster will be 83 feet long, weigh 130,000 pounds and, with solar panels extended, look like a huge flying windmill.

After the Saturn 5 has boosted the

*(Text continues on page 110;
Skylab painting on page 108)*

SKYLAB: America's First Space Habitat

Artist's concept shows Skylab's three-man crew in orbital workshop (right) and engaged in extravehicular activity—replacing film in the Apollo telescope mount. Only two astronauts are needed to make the film exchange—one on top of the telescope mount and a second just outside the airlock hatch. In painting, the second man is hidden by arm of ATM's solar array.



Painting by Aerospace Artist Ed Valigursky

NASA

METEOROID SHIELD

METABOLIC ACTIVITY
ERGOMETER AND EXERCISER

CREW'S QUARTERS

SLEEP COMPARTMENT

TOTAL WORKSHOP (OWS)

ALUMINUM
GRID CEILING

SOLAR
PANELS

WATER
TANKS

WASTE TANK

TRASH DISPOSAL

ALUMINUM GRID FLOOR

LOWER BODY NEGATIVE-
PRESSURE DEVICE

WASTE MANAGEMENT
COMPARTMENT

WARDROOM

PASSAGEWAY TO
"UPPER" LAB

SHIRT-SLEEVE ENVIRONMENT-
OXYGEN-NITROGEN ATMOSPHERE

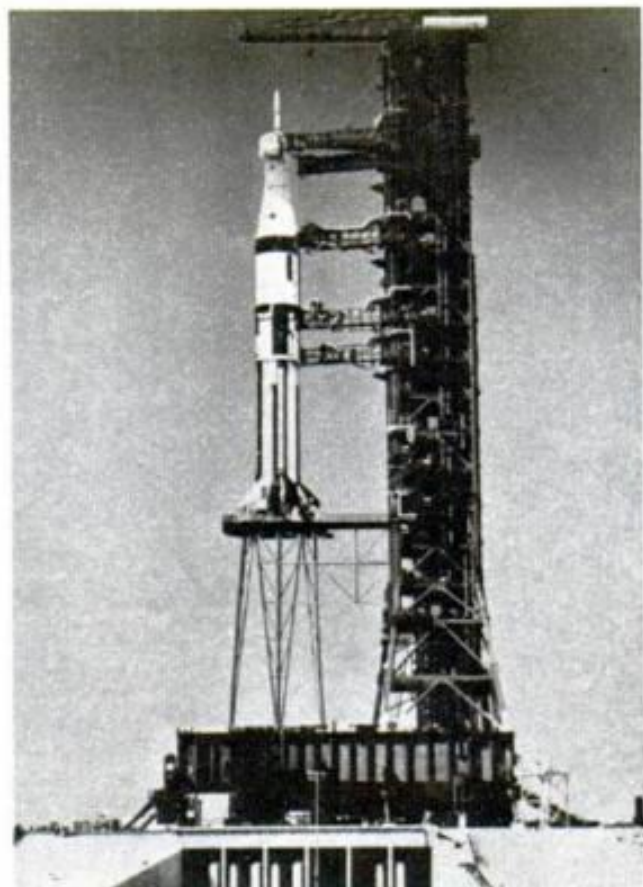
HANDRAIL

ASTRONAUT TESTING
PROPULSION DEVICE

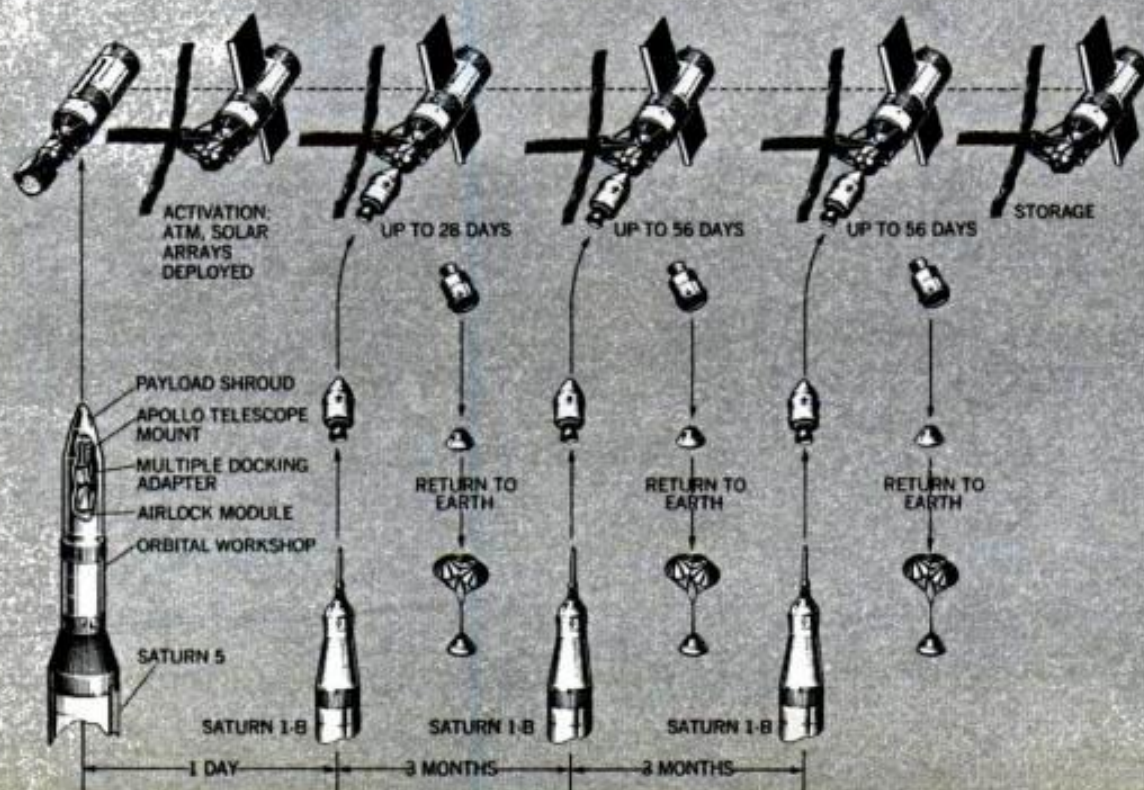
AIRLOCK MODULE (AM)

workshop—the modified S-4B third stage—and the other components into orbit, the cluster's telescope mount and its solar arrays will deploy. Then the crew will be orbited by a Saturn 1-B, the two-stage rocket used in the early Apollo Earth-orbit missions. After five orbits to permit maneuvering, the astronauts will guide their Apollo command and service module to a rendezvous with the workshop cluster. They'll dock the CSM at a port at the end of the multiple docking adapter and enter the cluster, moving through the airlock module into the workshop.

Compared with the cramped quarters of the Apollo command module, Skylab is a "mansion" of 13,000 cubic feet, which makes it larger than the average three-bedroom house. The biggest unit is the orbital workshop—a 48-foot-long cylinder with an interior diameter of almost 22 feet. Though there is no "up" or "down" under zero-G conditions, the workshop is divided into a two-story configuration. Open aluminum grids are used for floors and ceilings. The "lower" (aft) story has a seven-foot ceiling and contains the crew's quarters, including sleep compartment (70 square feet), ward-room (100 square feet) and waste man-



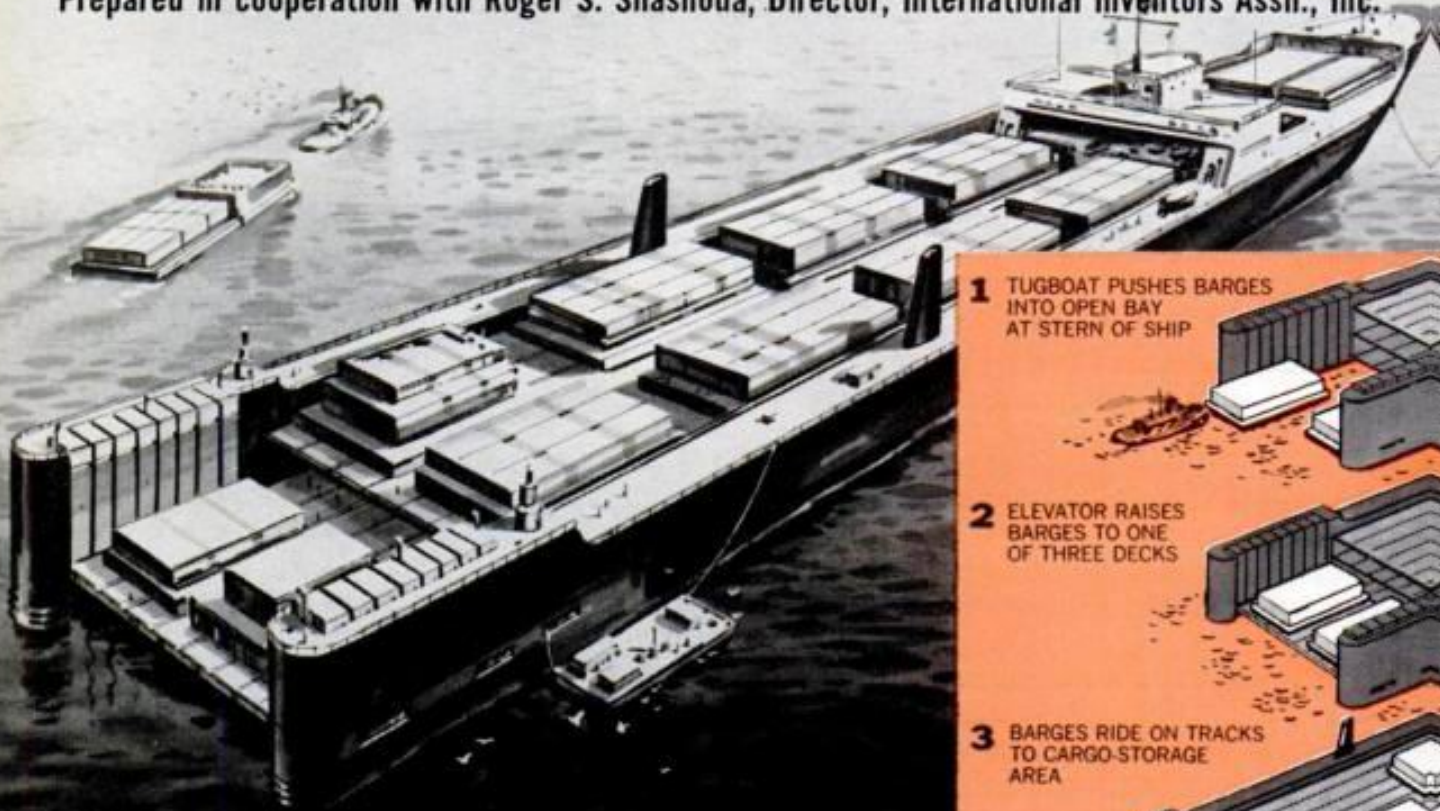
Profile of Skylab Mission



Just patented

PM'S PICK OF THE NEW INVENTIONS

Prepared in cooperation with Roger S. Shashoua, Director, International Inventors Assn., Inc.



1. FULLY LOADED BARGES are carried piggyback by this giant ocean-going transporter. The idea is to speed overseas shipments by eliminating the tedious job of transferring cargoes from barges to larger freighters. The barges are floated into a water-filled bay at the stern of the transporter, then a huge elevator lifts them to one of three storage decks. There, they're rolled along on tracks and stacked in rows for the trip. At their destination, the loaded barges are launched by the elevator and continue on to foreign ports through inland waterways

1 TUGBOAT PUSHES BARGES INTO OPEN BAY AT STERN OF SHIP

2 ELEVATOR RAISES BARGES TO ONE OF THREE DECKS

3 BARGES RIDE ON TRACKS TO CARGO-STORAGE AREA

Illustrations by Roy G.D.

2. REVOLVING PLATFORMS on the novel railroad cars below are designed to permit fast loading and unloading of military vehicles, cargo vans and heavy construction equipment. Hydraulically operated

ramps at the ends of the platforms swing down to the ground so vehicles can be driven easily on and off the cars. When they're retracted, the ramps become barriers to help keep the vehicles in place



Just patented

PM'S PICK OF THE NEW INVENTIONS

Prepared in cooperation with Roger S. Shashoua, Director, International Inventors Assn., Inc.



Art by Roy Grinnell

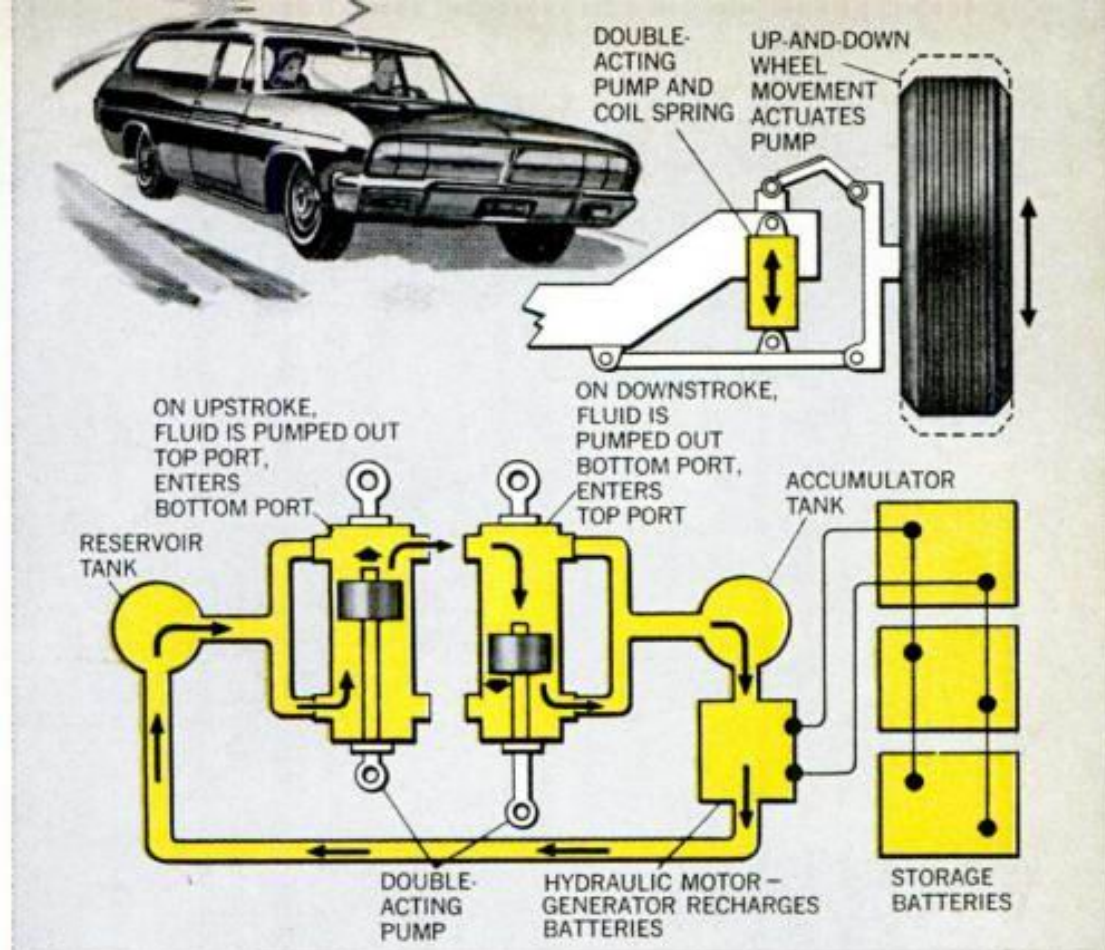
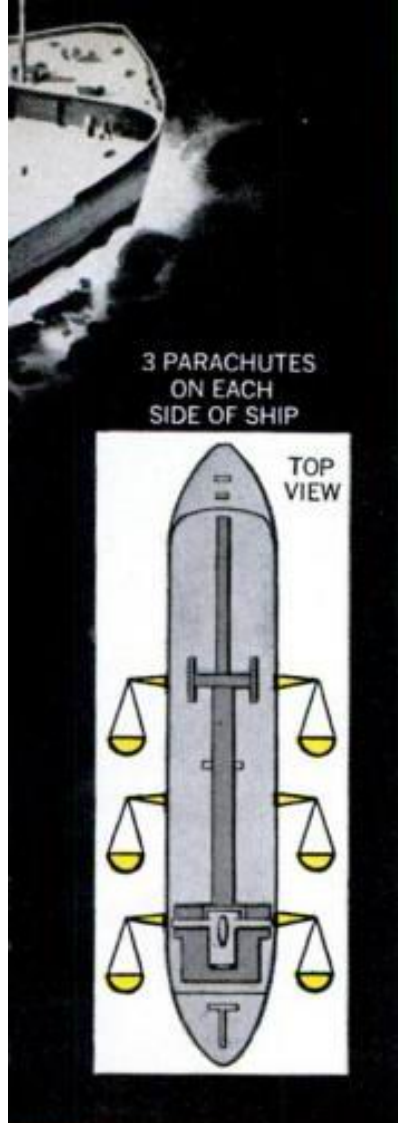
1. UNDERWATER PARACHUTES serve as "brakes" for big ships, helping to stop them faster and make them more maneuverable in congested waters. Designed for use on supertankers and heavy cargo vessels, the chutes can be extended all at once or one at a time, depending on the amount of drag desired. By

deploying only those on one side, they can also be used to help steer a ship in the same way a tank or bulldozer is turned by braking one track. The chutes are said to be much safer than an emergency reversal of engines because, in the latter case, the bow frequently swings dangerously out of control



2. PAPER CLIPS POP OUT of this novel dispenser by themselves, ready for easy removal without your fumbling around for them. The secret is a ring magnet around the rim. As clips are pulled out, others are drawn up in their place by the magnet. The dispenser can also hold pins, tacks and small nails

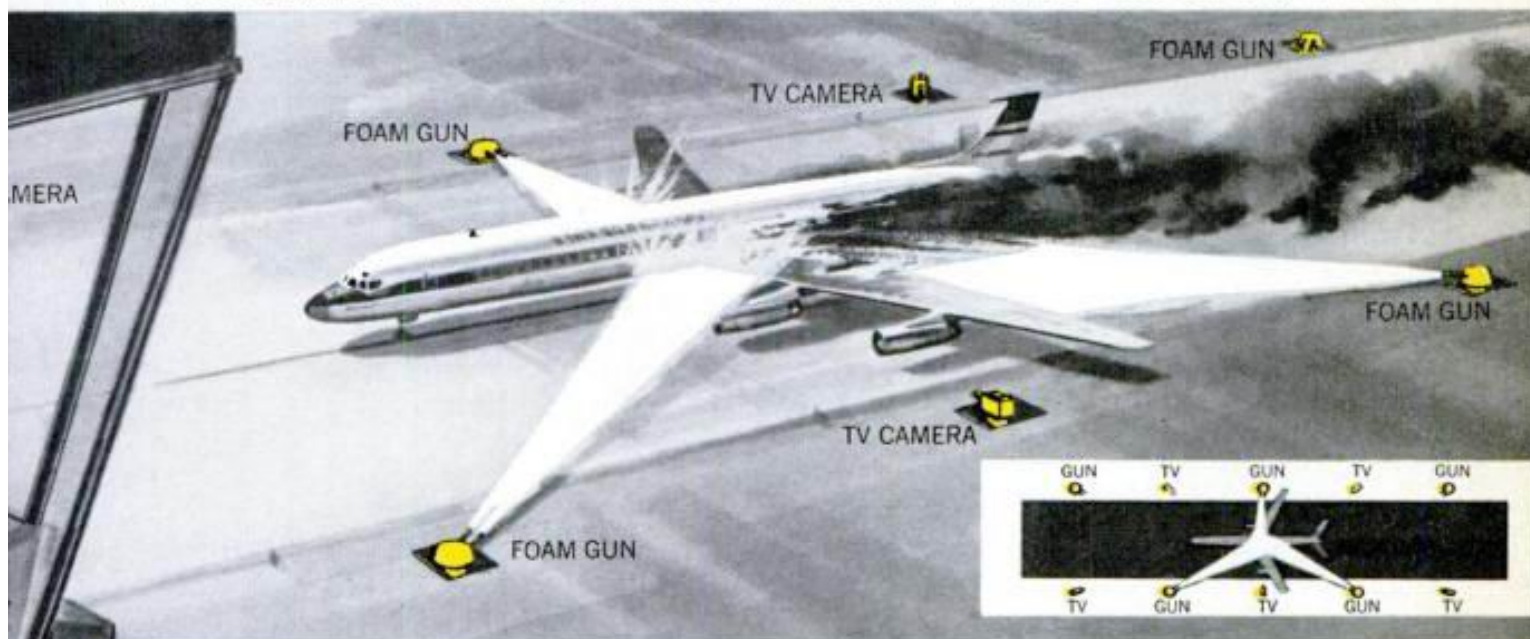




3. SELF-GENERATING ELECTRIC CAR uses the motion of its own wheels to add supplementary power in the ingenious system shown above. Double-acting pumps installed in the place of shock absorbers drive a fluid-powered generator to help keep the batteries charged as the car moves along. The system is not designed to supply total power, but to permit longer runs between recharging stops.

4. FOAM-SPEWING GUNS literally shoot out airport fires in the emergency system shown below. Installed at intervals along the runway, they follow a flaming airliner as it lands, spraying it with foam and putting out the fire before the craft even comes to a stop. TV cameras also follow the plane.

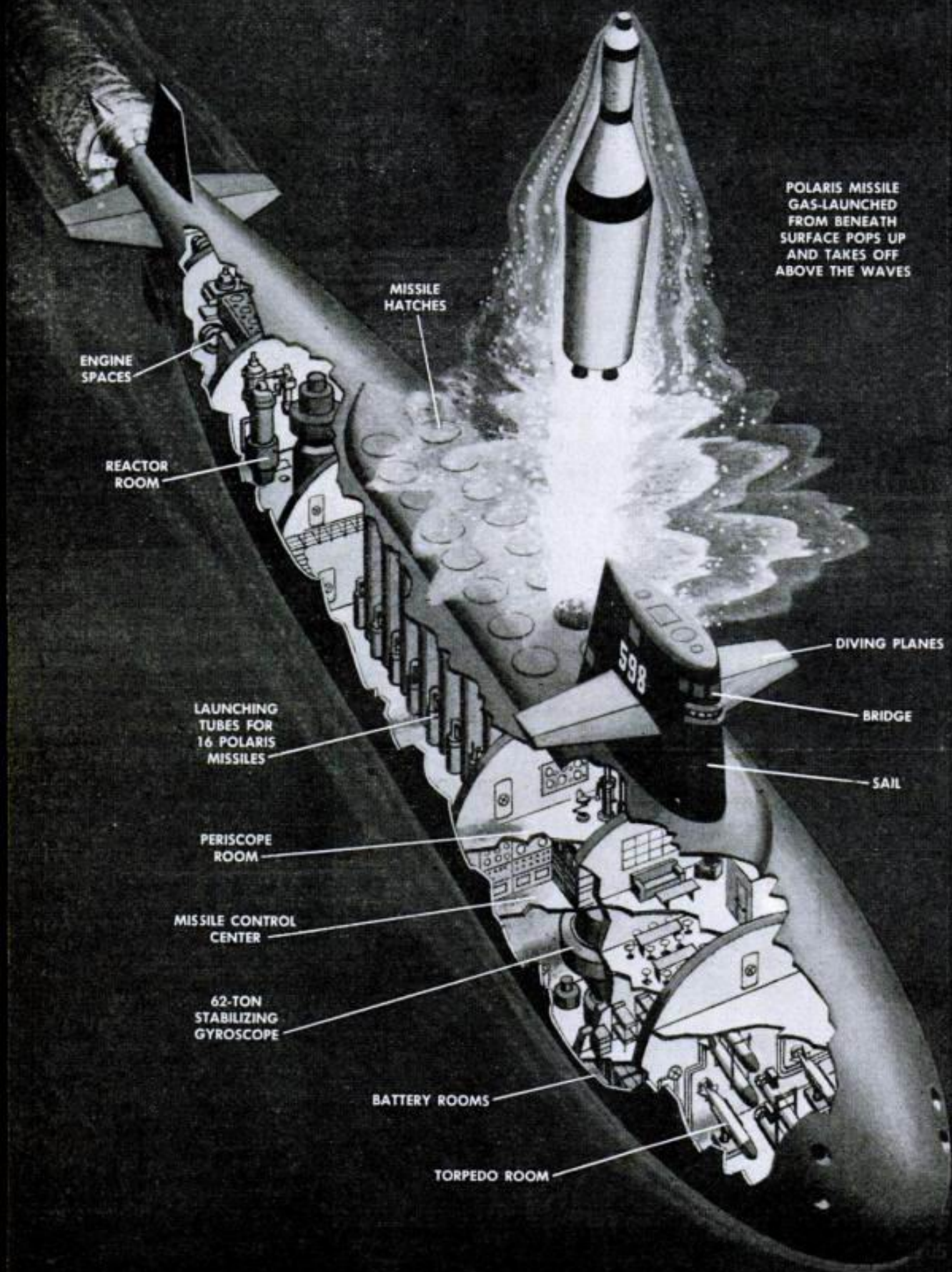
showing its position on monitor screens in a master control console. From these, the console's operator can tell where the plane is on the runway and which foam guns to activate. The system can also be used to spread foam quickly on a runway if a disabled liner is about to make a wheels-up belly landing



Inventors of the items shown on these pages are as follows: 1. Mitsubishi Heavy Industries, Ltd., Marunouchi, Chiyoda-ku, Tokyo, Japan; 2. Mailatol, Ltd., 119 Red Lion Rd., Tolworth, Surrey, England; 3. Landon H. Howard

and Benjamin T. Howland, 2841 Monogram St., Long Beach, Calif.; 4. Karl-Heinz Engel, Priessnitzstr. 7, 6277 Camberg/Taunus, West Germany. International Inventors Assn. is located at 680 Fifth Ave., New York, N.Y. 10019.

THIS MAKES THE TORPEDO CHILD'S PLAY



We're Going to Work Miracles

The atom's power is ready to unlock a treasure chest of arctic oil, dig open an Alaskan harbor, open the spigot for Colorado's shale . . .

By Dr. Edward Teller

WHEN YOU LOOK AT A MAP of Alaska, you will observe Point Hope, at the northwest corner, projecting out into the Arctic Ocean. Above Point Hope the shore is exposed to the polar ice pack—which even in summer is never far offshore. Ships can travel north of this point only one month in twelve.

But below Point Hope, the shore swings to the southeast and the sea is free of ice three months of the year. Nearby are coal deposits and, somewhat farther, oil that might attract commerce except for one vital lack: There is no harbor, no good anchorage for seagoing ships.

If all goes well we expect to make an artificial model harbor on this bleak coast in the spring of 1961. It will be a small harbor, and yet it will be an

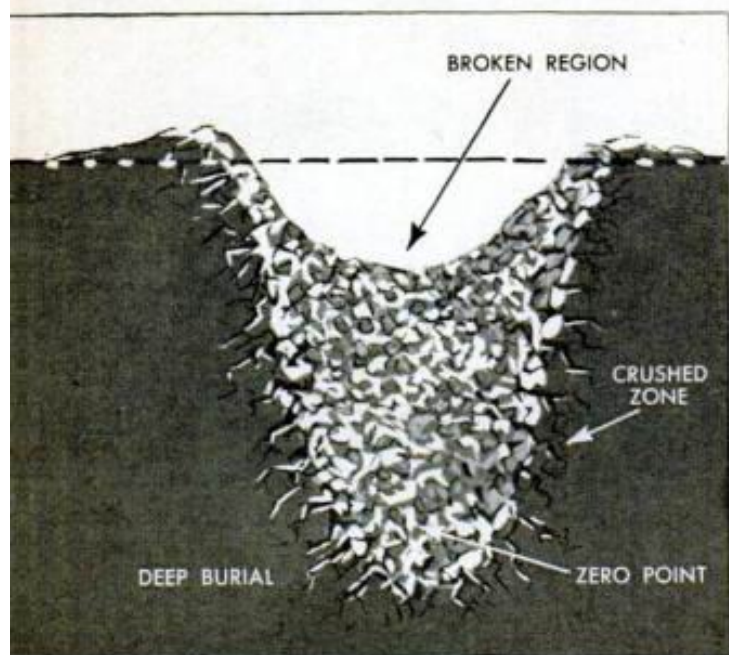
Dr. Edward Teller, "father of the hydrogen bomb," is director of the University of California Radiation Laboratory at Livermore





In a matter of milliseconds, five nuclear bombs will blast open a new harbor in Alaska. The channel will be 1800 feet long and 750 feet wide; the inner harbor, about a half mile long and a quarter mile wide

Deep-buried bombs fling only surface material into air. Radioactive substances stay near the zero point



experiment of great hope for the future. The harbor will be excavated in an instant—in a matter of milliseconds—by the explosion of five nuclear bombs having approximately as much power as 500,000 tons of TNT.

In that tiny interval of time this energy will move 20 million tons of earth and rock. It will blast out a channel 1800 feet long and 750 feet wide and at the same time create an inner harbor a quarter of a mile wide and half a mile long. The minimum water depth will be around 30 feet.

The site is 100 miles north of the Arctic Circle, below Point Hope and Cape Thompson, at the mouth of Ogotoruk Creek.

Project Chariot, as the harbor is called, may become very worthwhile in the years to come, but it is intended mainly as a demonstration that will usher in the age of peaceful uses of atomic explosions. We expect to show that this new kind of power can perform large earth-moving jobs with proper safety and at less cost than conventional methods.

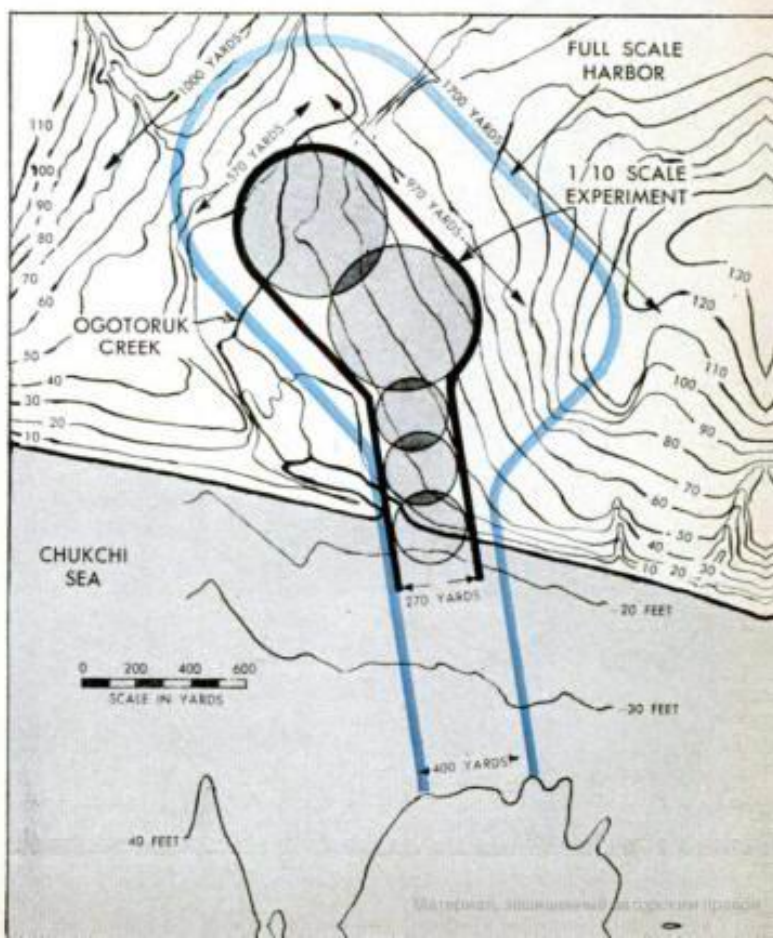


The remote site was chosen deliberately to allay any fears of radioactive contamination. However, there will be very little contamination. To accomplish this, we will use a trick to prevent the possible escape of fission products.

If the nuclear devices were to be exploded at shallow depths, almost all radioactive particles would be thrown up into the atmosphere. So we will bury the bombs deep—about 400 feet below the surface for the small ones and possibly 700 feet for the larger ones. Each blast will transmit its energy to the rock above it, flinging only the surface materials into the air.

We expect that all except 10 or 20 percent of the radioactive byproduct will be trapped at the deep zero points and we hope that it will remain practically immobilized in the fused rock. It is possible that we shall succeed even better and that all but a very small percentage of the radioactivity will be safely contained underground. In a short time, possibly two weeks, it will be

Shading indicates Project Chariot harbor; the blue line shows how harbor can be enlarged, if desired



possible for people to work safely in the immediate vicinity of the explosion.

The mechanics of this are based on several underground test shots that have been made at our Nevada test site. The bombs ranged from one tenth of a kiloton to 23 kilotons in power and were detonated at different depths below the surface. From these experimental shots, we learned a great deal about underground blasts and how much fallout to expect.

Preparations for building the Alaskan harbor are under way now. Last summer 140 people from the Atomic Energy Commission, other government organizations and several universities started surveys in the area. They are studying the geology and making biological surveys of the plant and animal life. They are investigating the food "chains" and the habits of the few local Eskimos, their food sources and their hunting and fishing areas.

Similar surveys will be made at some future date after the creation of the harbor. Thus we will learn whether any local conditions were changed by the blasts. This is indicative of the care and caution with which we are approaching this first large demonstration.

I believe that the dangers from fallout in the weapons-testing program have been greatly exaggerated; nevertheless, this worry exists and so we are trying to develop "clean" bombs. Within a few years,

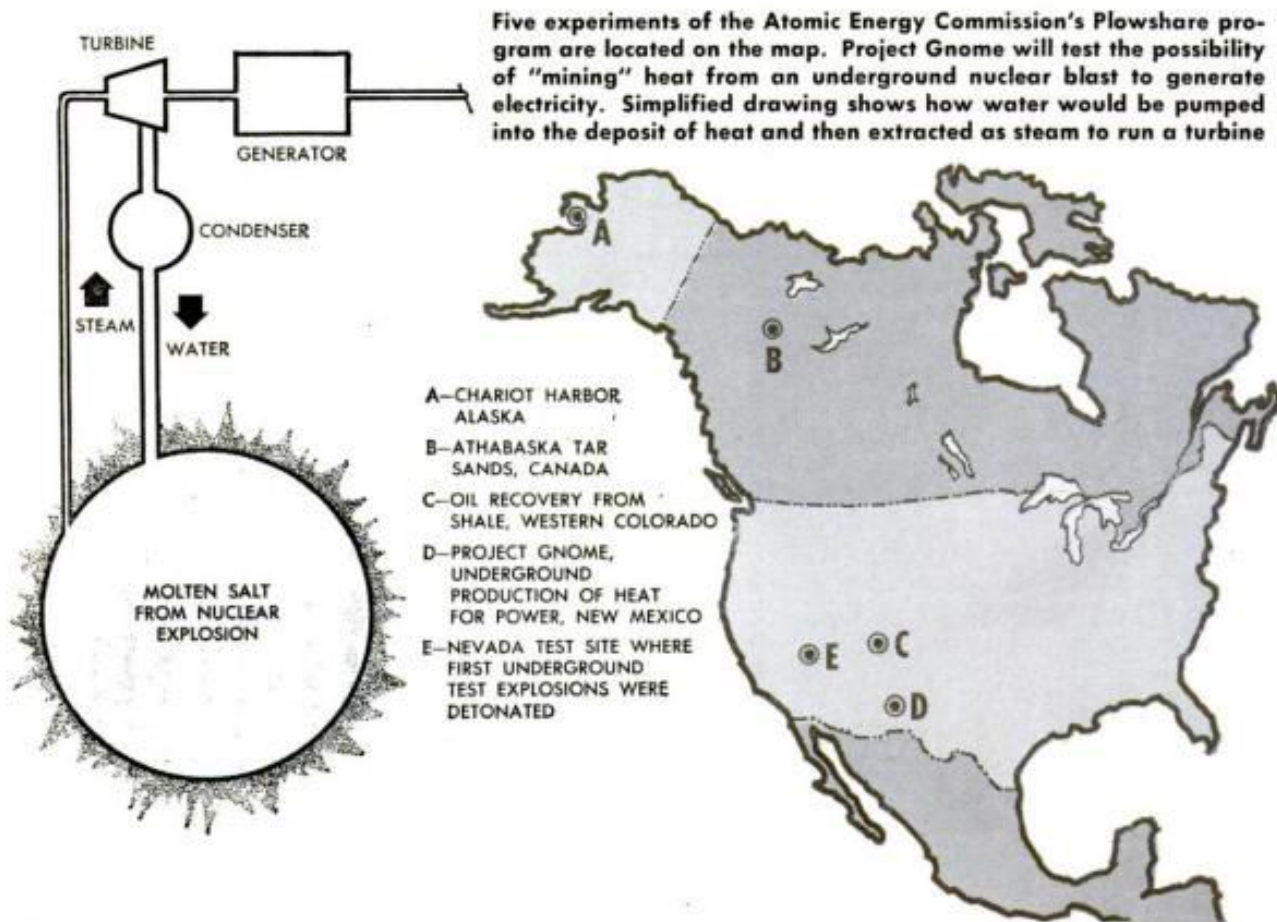
we may be able to produce explosives that are completely clean, with no radioactive fallout and no local residual contamination.

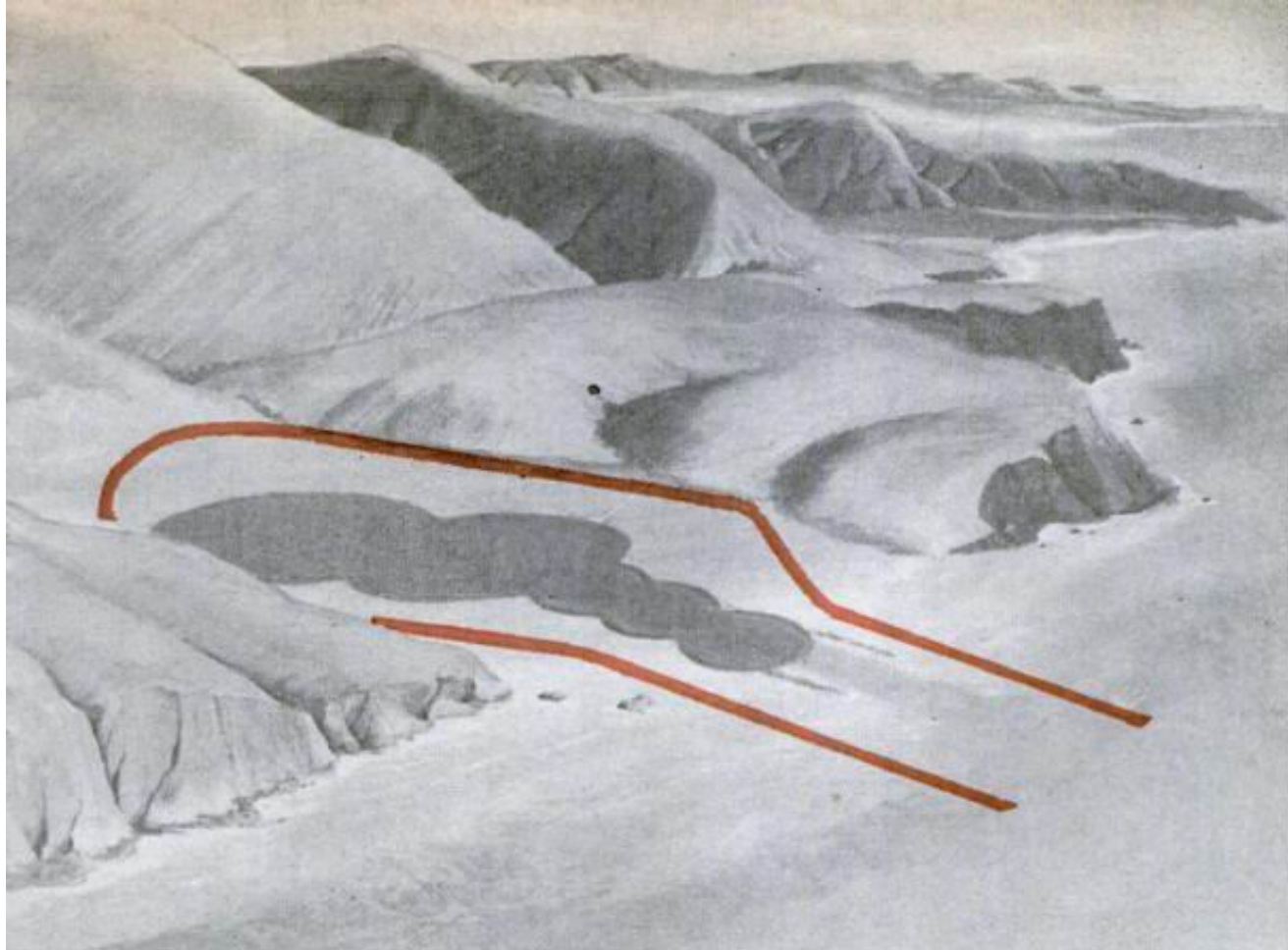
Project Chariot is part of the AEC's Plowshare program for exploring constructive, peaceful uses of nuclear explosives. Studies have been going on for several years and the whole Plowshare subject is now declassified with the exception of the black box that contains the nuclear explosive itself and which we might call Hamlet, as it is the main actor in the drama. Our present necessary secrecy requires that Hamlet shall not appear on the stage for the time being.

If Chariot is successful, we will have the knowledge and experience for creating a harbor wherever one is needed. Its size and shape can be tailored to the local requirements. Several future locations have been considered, as has the possibility of sea-level canals that would be dug in roughly the same fashion as Chariot's entrance channel.

With similar techniques, we can remove the overburden from large bodies of low-grade ore and at the same time shatter the ore so that it can be mined by ordinary means or by one of the suggested leaching processes. Deep ore bodies that are too expensive to mine today may also yield to nuclear mining.

The AEC has established estimated charges for nuclear explosives, including





Project Chariot in Alaska not only will test the possibility of excavating a harbor by nuclear bombs but will also make accessible nearby coal and oil deposits. If needed, the harbor can be expanded to the red line

their emplacement by the commission. Estimates range from a half million dollars for a few-kiloton yield to a million dollars for a megaton bomb. Larger ones would cost only a little more. Future developments may decrease the charges. For the kinds of work we have in mind, we believe the nuclear explosives are cheaper than conventional explosives and in some cases can do work that is quite impractical by any other means.

People talk about putting the cart before the horse, and in this absurd age this is not so unusual; all of us have seen horses carried along in trailers. In a somewhat similar way, we may be able to use nuclear energy to make available more of the old conventional fuel which nuclear energy is supposed to replace. In particular we might use nuclear explosions in oil production.

Why should anyone do that? Because a nuclear reactor emits dangerous radiations and so needs heavy shielding, which makes it clumsy as a motor for a small vehicle. Furthermore, an accident to any moving vehicle driven by a reactor might get us into real trouble. If fission products stored up in the reactor get loose, there will be enough concentrated radioactivity in the neighborhood to constitute a serious hazard. For the purpose of transportation, the light and compact energy package that is gasoline or oil remains better than anything else known or expected. Yet our in-

expensive oil stocks are nearing the point where their decline can be foreseen.

It might be possible to extract more petroleum from deposits that are regarded as depleted by exploding nuclear devices in the formations, shattering the oil sands and perhaps also providing the heat so that the oil may flow more freely.

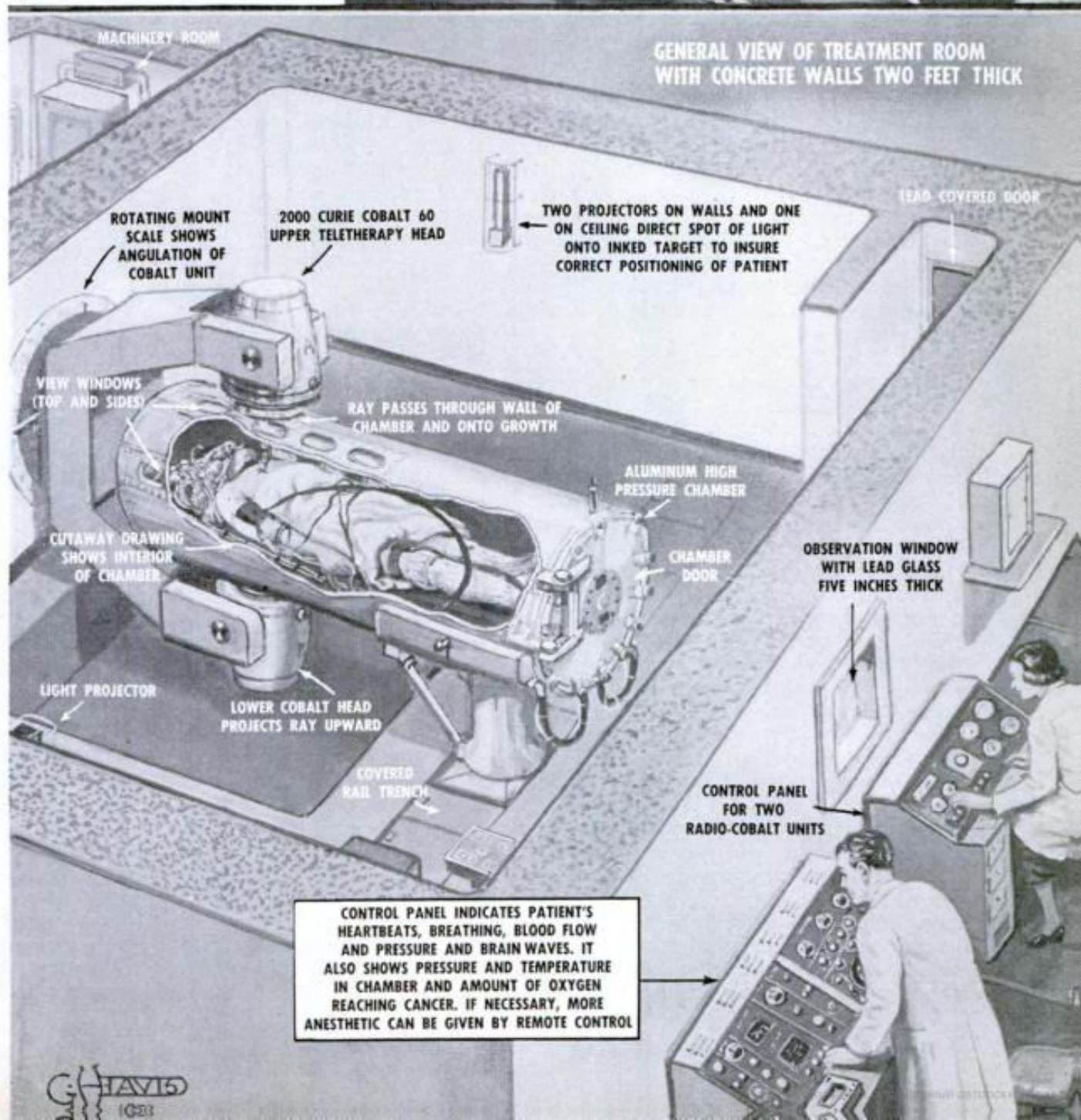
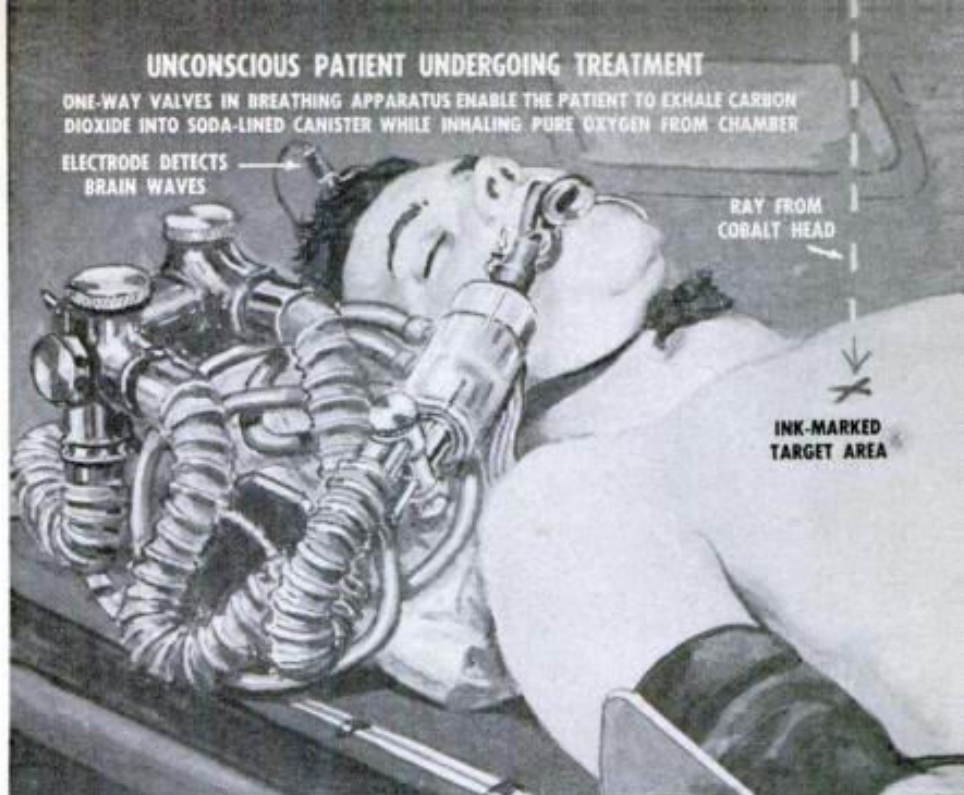
In the Athabaska River region of north-west Canada there exists a tar sand that contains as much petroleum as all the oil of Arabia. On a hot day the tar drips from the exposed banks, yet no cheap way of extracting it has been found.

A proposal that is being studied by the Canadian Government and the Richfield Oil Company is to explode a 10-kiloton charge at the bottom of a 1200-foot hole in the Athabaska tar sands. From what was learned at the underground test shots in Nevada, we would expect the explosion to create a huge bubble in the earth which almost at once would fill up with shattered rock falling from above. We hope that the radioactive products of the explosion will be trapped in the bubble's glassy lining. If the rock in and above this bubble is sufficiently broken up, and if the material does not get compacted and does not resolidify too rapidly, we have opened a passage for a heating fluid to the tar sands and we can thaw out the petroleum. In fact, the heat of the explosion itself might be used.

(Continued to page 278)

High-Pressure Oxygen Aids in Radiotherapy

ENCOURAGING results are reported by St. Thomas' Hospital, London, in treating cancer by high-pressure oxygen and radiotherapy. Anesthetized patients in the apparatus—first of its kind—breathe high-pressure oxygen. This assures a normal concentration of oxygen around cancer cells—which are often deficient in oxygen and thus up to three times less sensitive to radiotherapy than normal cells.



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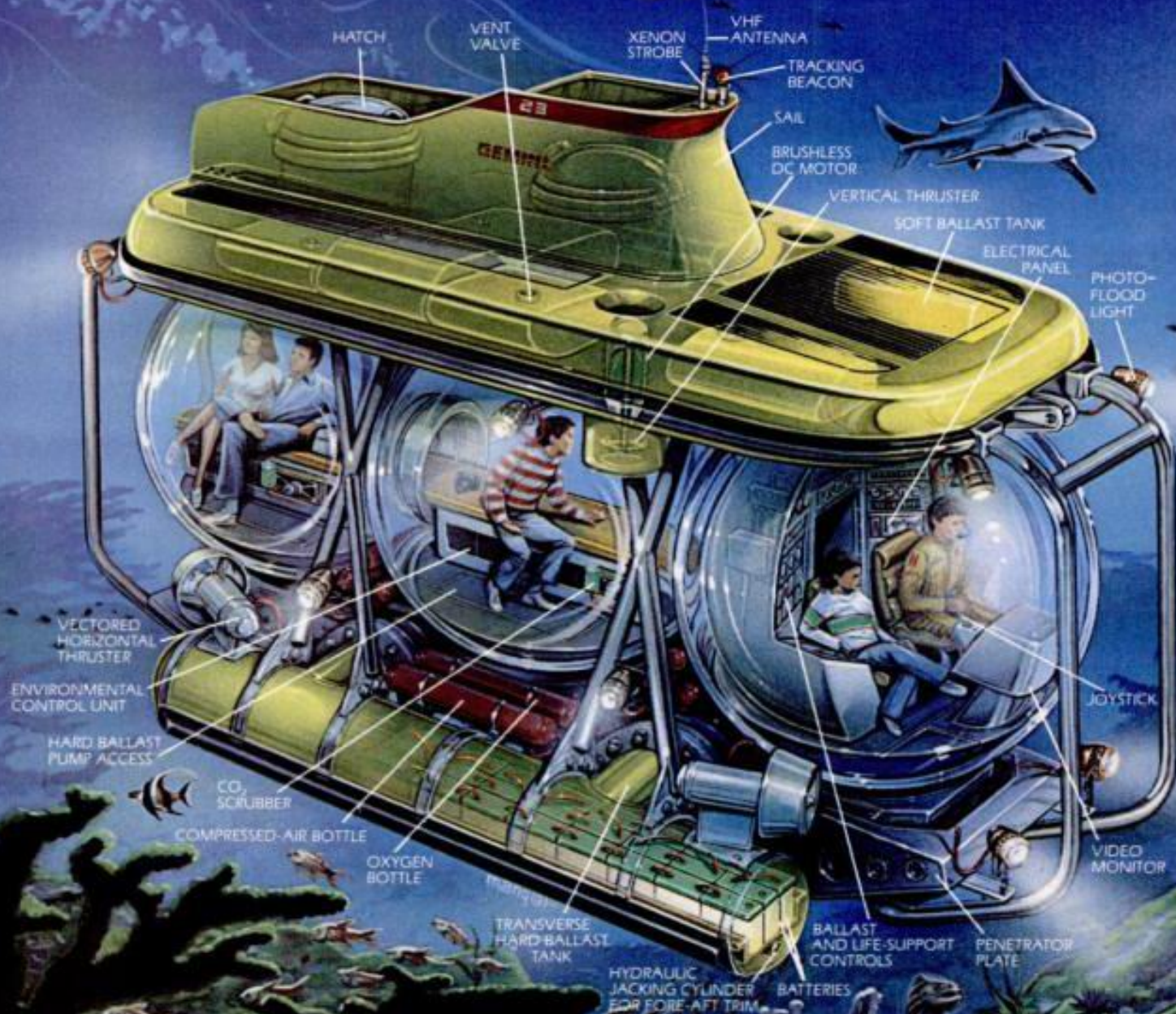


COVER STORY

TOURING THE DEEP

Submersibles made of transparent acrylic spheres offer a new way to view the ocean's fascinating riches.

BY GREGORY T. POPE; PM Illustration by Jeff Mangiat





I WATCHED an alien blue world drift slowly past the viewport. Gnarls of limestone, some spindly lifeforms, and the jetsam of civilization—everything looked close enough to touch, thanks to the fisheye effect of our hemispherical window. Sparks flashed as bioluminescent organisms bounced off the transparent acrylic. The scene had the same ghostly hue and limited visibility of a moon-lit landscape.

"PC 1203 to chase, we're at 800 ft., 8-0-0," said pilot Courtney Platt behind me. He waited for the acknowledgment to crackle through the speaker, then flipped an overhead valve. A harsh gurgling sound ensued, as a pump blew water out of a ballast tank to slow our descent.

We were floating down the side of an undersea mountain—a quarter-mile off Grand Cayman, about 200 miles south of Cuba. Our destination lay cradled by two limestone pinnacles on the mountain's shoulder—the *Kirk Pride*, a cargo ship that had sunk six years previously. Our

vessel: a veteran research submersible, pulled out of early retirement to make deep waters accessible to the layman.

A 12-year-old *Perry*-class workhorse, PC 1203 was built to carry oil-seeking oceanographers during the boom years of undersea exploration. These days, put out of work by cheaper remotely operated unmanned subs, she carries tourists.

The vista from PC 1203's viewport gave me a foretaste of a new generation of submersibles being built exclusively for tourism. The most innovative of these craft will feature hulls made entirely of transparent acrylic, for panoramic views of ocean depths well below scuba-diving limits.

The see-through submersibles will clearly outclass PC 1203 and her sister subs. Not that PC 1203 isn't reliable, beloved by both her current pilots and the commercial exploration outfits that can't afford her in these oil-glutted '80s. But she's a dinosaur with her sweating 4-in. steel walls, noisy hydraulic systems and scant elbow room. Comfort is the watchword for the new subs—

Windows on a watery world: *Gemini* submersible (opposite) and *Aries* submersible (above) will transport amateur aquanauts to unprecedented depths. Clear 6-in.-thick acrylic hulls will provide unrestricted views from personnel modules.

COVER STORY

SUPERTRAIN

New superconductors rekindle interest in levitated locomotives.

BY GREGORY T. POPE

CONDUCTIVE
ALUMINUM
GUIDEWAY SHEET

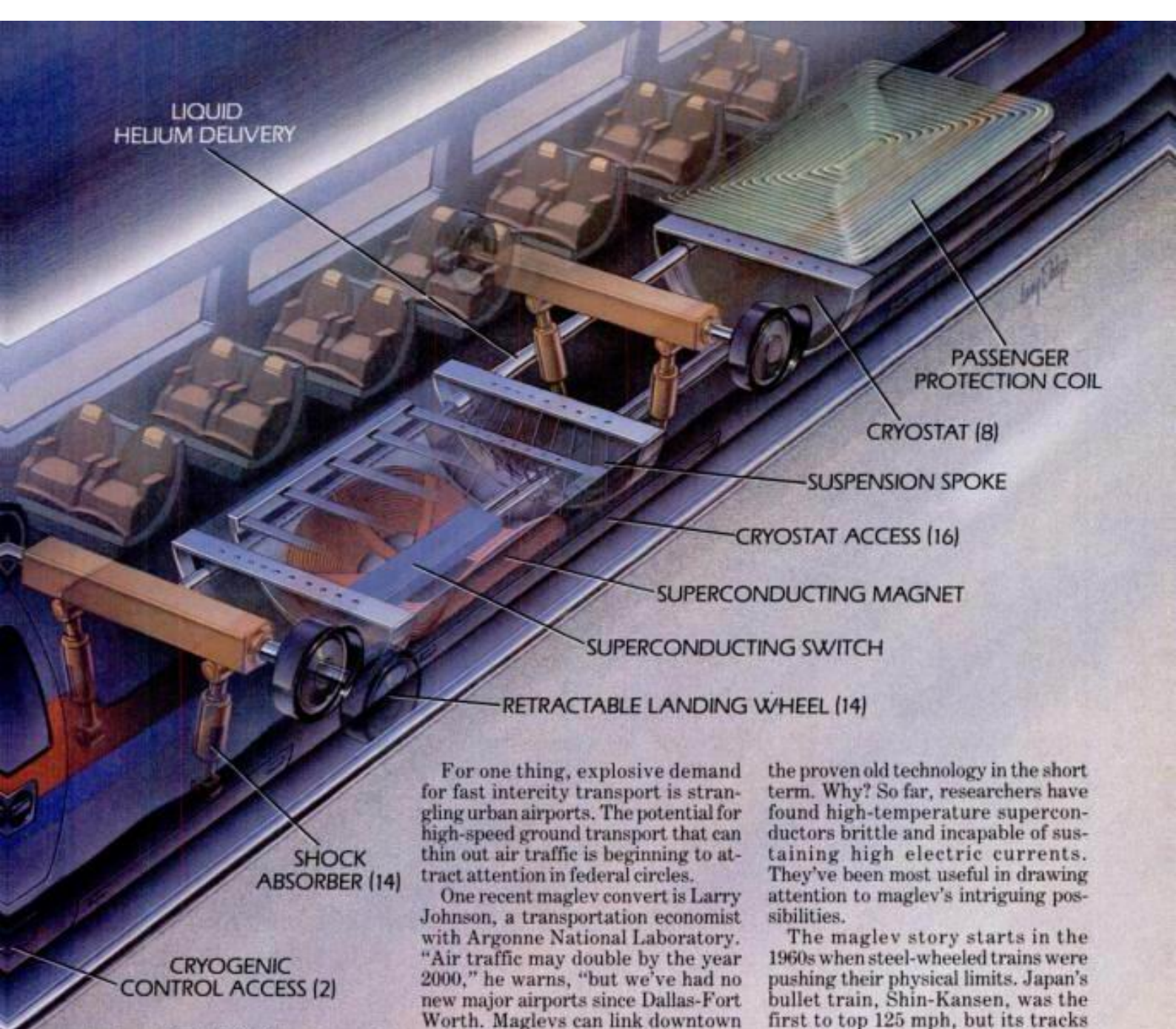
3-PHASE PROPULSION
WINDING

ESCAPE HATCH

ANTENNA

RIM TRACK FOR
LANDING WHEELS

A U.S. maglev concept, Magneplane floats on magnetic cushion. Superconducting magnets, housed in semicylindrical cryostats along vehicle's belly, provide lift by inducing opposing eddy currents in guideway's conductive sheet. Retractable landing wheels deploy at speeds under 40 mph. Propulsion winding in guideway track carries electromagnetic wave that pulls train's magnets.



LAS VEGAS, June 1, 2050—With 96 Los Angeles-bound passengers, the aerodynamic 1-car train begins its descent from the elevated station. Hard plastic wheels roll along the rims of the track, or guideway, and hum as the train gains speed. Thirty mph . . . 40 . . . then the wheels retract into the body of the vehicle as it reaches a straight "acceleration track." Suspended a foot off the guideway, the train gains momentum until it slices through the air at 300 mph, hissing like a huge rigid snake.

We're riding aboard a maglev, or magnetically levitated train. A long time coming, this futuristic shuttle has already arrived in certain areas of the world. The technology behind its floating magic has been feasible for over a decade. But only recently have developments taken place that could lead to the United States' first commercial maglev.

For one thing, explosive demand for fast intercity transport is strangling urban airports. The potential for high-speed ground transport that can thin out air traffic is beginning to attract attention in federal circles.

One recent maglev convert is Larry Johnson, a transportation economist with Argonne National Laboratory. "Air traffic may double by the year 2000," he warns, "but we've had no new major airports since Dallas-Fort Worth. Maglevs can link downtown areas 200 to 400 miles apart much faster than airport connections."

Last year's breakthrough in high-temperature superconductivity furnished another incentive for an American maglev. Suddenly researchers are scrambling to find work for the new superconductors, ceramics that carry electricity without resistance when chilled with liquid nitrogen. One potential large-scale application: Powerful yet compact electromagnets. The near-term maglevs of the 1990s may fly on conventional electromagnets. But the maglevs of the 21st century will float on so-called electrodynamic suspension systems that depend on big magnets made of superconducting materials cooled with liquid helium.

The new-technology nitrogen-cooled superconductors would use far simpler refrigeration systems. But both American and Japanese maglev engineers say they're sticking with

the proven old technology in the short term. Why? So far, researchers have found high-temperature superconductors brittle and incapable of sustaining high electric currents. They've been most useful in drawing attention to maglev's intriguing possibilities.

The maglev story starts in the 1960s when steel-wheeled trains were pushing their physical limits. Japan's bullet train, Shin-Kansen, was the first to top 125 mph, but its tracks need nightly realignment. Today's wheeled speed-recordholder, France's 163-mph TGV, runs on tracks that can't deviate by more than 0.16 in. without risking derailment.

Backed by their governments, American, Canadian, British, German, Romanian and Japanese researchers began studies. The motivations were clear: Besides solving transportation worries, maglevs would be environmentally benign, use $\frac{1}{10}$ th the energy of electric trains, and need less maintenance, thanks to friction-free locomotion. But in 1975, while overseas maglev projects took off, the U.S. initiative was abruptly grounded by a funding cutoff.

Push or pull

Today, maglev concepts exist in various stages of maturity. They call for either attraction (electromagnetic) or repulsion (electrodynamic) suspension to get off the ground.

SUPERTRAIN

Around the world by maglev (clockwise from top): Japan's electromagnetic 100-mph HSST, slated for Las Vegas; England's electromagnetic 25-mph Birmingham people mover, proposed for Atlantic City, N.J.; Japan's electrodynamic 250-mph MLU, still in prototype stage; West Germany's electromagnetic Transrapid, one generation from commercial service and current maglev speed king at 252 mph.



HSST PHOTO



TRANSRAPID PHOTO



AMERICAN MAGLEV PHOTO



JAPAN RAILWAYS PHOTO

With attraction suspension, the car carries conventional electromagnets powered by on-board batteries. The magnets—cobalt-samarium coils wrapping iron cores—line the inner lip of a flange on the car that's slung beneath the rails. Once powered up, the magnets in the flange are attracted upward toward the rails, and the vehicle defies gravity. With the repulsion system, magnetic force generated by cryogenic coils in the belly of the train push against an opposing magnetic force in the guideway.

Right now, attraction systems are closer to revenue operation than repulsion levitation. In Birmingham, England a low-speed electromagnetic people mover—the world's only operating maglev—has shuttled passengers from rail station to airport since 1985. An American company is working to implement the Birmingham system in Atlantic City, at New York's LaGuardia Airport, and even in the subway tunnels of Manhattan. Meanwhile, by 1990 Japan's intermediate-speed HSST—which carried Emperor Hirohito among 600,000

Expo '85 visitors—will be whisking gamblers from downtown Las Vegas to the casino strip.

But neither system is designed to top 125 mph. High-speed electromagnetic levitation is the exclusive domain of Transrapid. A product of a government-supported West German industrial consortium, Transrapid is the only high-speed maglev that is one generation away from commercial reality. In December 1987, a 196-seat prototype set a maglev speed record of 252 mph. How does Transrapid reach its breakneck velocity? Like all maglevs, its propulsion system is based on a linear motor. Consider an ordinary rotary-type magnetic motor. Current-fed coils on the external stator produce a coordinated magnetic force that turns the internal rotor. Now imagine cutting the motor and laying it out flat. Instead of rotating, the magnetic force races along a line.

In Transrapid, wayside power substations feed current to the guideway. A computer tracks the position of the train and energizes only the section of the guideway over which the train is

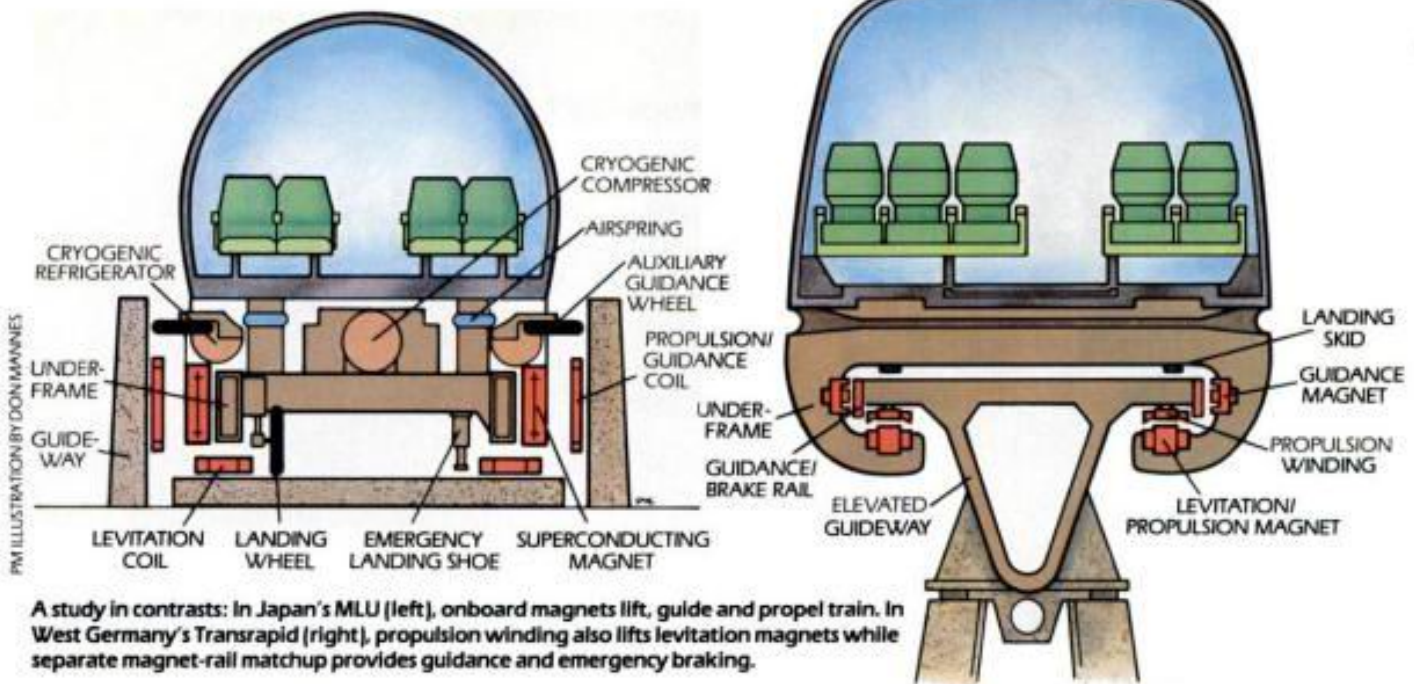
moving. The current surges through 3-phase windings along the bottom of the twin rails, generating a traveling magnetic force.

The train rides like a surfboard on this magnetic wave, which grips and propels the vehicle's levitation electromagnets. Speed is controlled by adjusting the voltage and frequency of the guideway current. This current also induces currents in supplementary coils on the vehicle—those coils charge the on-board batteries. Meanwhile, a second set of magnets keeps the train aligned with the rails.

But there's one major drawback in an electromagnetic suspension system like Transrapid—inherent instability. The attraction force becomes stronger if the vehicle's magnets approach the rail. Keeping a constant clearance gap—about $\frac{3}{8}$ in.—is essential. For Transrapid, that has meant very precise track construction and a complex suspension control system. Sensors constantly monitor the gaps and send information to a microprocessor that adjusts the current flowing to the electromagnets. If

ELECTRODYNAMIC (REPULSION) SYSTEM

ELECTROMAGNETIC (ATTRACTION) SYSTEM



track flaws or vibrations bring the magnets too close to the rail, power is lowered and the attraction force weakens.

Attraction levitation—though a more mature technology—may be overtaken by repulsion levitation because of the stability problem. At the moment, two repulsion-mode systems look most promising for high-speed applications. One is a full-scale experimental Japanese maglev: the MLU. The other is Magneplane, the radical American design mothballed in 1975 after the cash flow dried up.

Electrodynamic, or repulsion, suspension works like this: A current runs around a moving coil that passes over a stationary coil. The current triggers magnetic flux which penetrates more and more of the passive coil as the moving coil passes over it. As long as the magnetic flux through the passive coil is either increasing or decreasing, it induces an opposite current in the passive coil which repels the moving coil. That repulsion generates lift. Only when the moving coil is directly over the passive coil is there no change in flux. The repulsion weakens, causing drag.

Put a series of coils on a moving maglev vehicle and stationary coils in a guideway, and you have an electrodynamic suspension system. The faster you go, the less time the moving coils spend directly over the passive coils. That means that electrodynamic drag, unlike aerodynamic drag, decreases with increasing speed. Like a plane at takeoff, an electrodynamic maglev rolls on wheels until it's moving fast enough for lift to overcome drag—usually at 40 to 50 mph.

But the real benefit to electrodynamic suspension is its natural stability. The repulsion force increases sharply if the vehicle coil approaches the guideway coil. Moreover, equipped with powerful superconducting magnets, the trains can float a foot off the guideway. That's more than enough room to tolerate guideway flaws.

Since the early 1970s the Japanese Railways Group (JRG) has been testing repulsion-levitation vehicles, the latest of which hit 250 mph. The system has basic electrodynamic suspension: passive coils sunk into a concrete guideway, with superconducting magnets on board the vehicle. Mount-

ed along the vertical sides of the guideway—face-to-face with the superconducting magnets—are coils linked by cable. Charged in rapid succession, they whisk the vehicle up to speed. Magnetic fields generated by these side coils also keep the vehicle lined up above the levitation coils.

The Japanese maglev has farther to go to reach commercial reality than Transrapid. On-board refrigeration is still a major hurdle. Though they use much less power than Transrapid's electromagnets, the superconducting magnets must be chilled reliably to -452° F. That requires complex, maintenance-intensive liquid-helium cryogenics. JRG engineers have made progress in shrinking the cryogenic apparatus, and they are currently experimenting with an integrated magnet-cryostat cassette.

Maneuverability is another question mark. The Japanese have tested their train only on a straightline run, whereas the Transrapid test track includes loops that the train handles easily.

Even farther down the line is Magneplane, the United States' best hope

(Please turn to page 114)



Repulsion levitation simplified: Current-carrying loop (as in a magnetic coil) moves over stationary passive ground loop. Lift occurs when magnetic flux penetration (in red) increases or decreases. Drag occurs when moving loop is directly overhead and diminishes at higher speeds.

TECHNOLOGY UPDATE

MILITARY



How to hide an aircraft carrier under water

Ever since World War I, military schemers have been intrigued by the prospect of launching fighter planes from submarines. Most attempts met with little practical success. But now the British have come up with an idea so audacious that it just might work. It's a submersible aircraft carrier fitted with a watertight hangar and a pair of long-armed double-jointed deck

cranes designed to launch and retrieve V/STOL jump jets like the famed Harrier.

The plan is based on the SkyHook launch system already under consideration for handling Harriers aboard small patrol vessels that lack sufficient deck space for conventional take-offs and landings (see *Skyhooks For Harriers*, page 181, Oct. '83). In a SkyHook launch, a crane

plucks a Harrier off the sub's deck, holds it in midair until it develops sufficient vertical thrust to hover under its own power, then it releases the plane and off it flies.

To land a Harrier, the procedure is simply reversed. The plane hovers under the crane's claw until a hookup is made, then cuts its power and the crane swings it back down on deck.

The SkyHook concept offers several advantages over vertical takeoffs and landings. It saves fuel by reducing hover time and enables planes to operate in seas too rough for safe deck landings and take-offs. It also speeds the deployment of aircraft, since one can be launched while another is being recovered. According to estimates, a returning Harrier could be refueled, rearmed and back in the air in about three minutes.

ROBOTICS

Walk this way...

Teaching robots to walk is one of the most difficult challenges facing science and engineering. But the challenge is being met in a variety of interesting ways. Engineer Ivan E. Sutherland and his associates have demonstrated a 1,600-pound, six-legged machine that carries a man who gives "joystick" commands for speed and direction. Hydraulic actuators in each leg determine precisely how high and in what direction the leg must move. It may be the prototype of a future vehicle for handicapped people. University of Tokyo researchers have developed the Biper robot, a two-legged model that can walk forward, backward and sideways. Controlled from a computer console, it is the first stage in development of a household "servant" robot. At Carnegie Mellon University, Marc Raibert is studying a one-legged hopping machine. Results are expected to include a four-legged running machine. Odetics of California is the first company to make a commercial walker. The Odex is being tested by the Army for minefield duty.



Ivan Sutherland rides six-legged hydraulic walker.

Within minutes of surfacing, this submersible aircraft carrier proposed by the British could launch V/STOL fighter/bombers at an unsuspecting enemy.



Potent new assault ship with a one-two punch

If future Marines ever have to hit an enemy-held beach, they'll mount their attack from a new dual-role amphibious assault ship that combines the aerial striking power of an aircraft carrier with the ability to launch and recover the Navy's fast, new air-cushion

landing craft. As the landing craft fly out of a huge bay in the vessel's stern, Harrier jump jets and attack helicopters will take off from a mini flight deck to provide protective air cover as troops fight to establish a beachhead.

The 844-foot, 40,500-ton

ship carries 2,000 troops, has a 600-bed hospital with six fully equipped operating rooms and can still do better than 20 knots. The first of the new assault ship class, the USS Wasp, will be constructed by Litton for delivery to the Navy in 1989.

Champion choppers

Russia's Mi-26 (near right) is undisputed champion as the world's most powerful heavy-lift helicopter with a payload capacity of 20 tons. But now we're about to top it. The Boeing Vertol XCH-62, currently under construction (far right), will lift a whopping 35 tons—75 percent more than the Mi-26. Looking like a praying mantis clutching its prey, the tall-legged, tandem-rotor monster will have a special cab slung under its belly to give the lift operator a clear view of the load. Abandoned 10 years ago for lack of government funding, the XCH-62 has now been revived and is expected to be operational by 1988.



During submerged operation, the cranes retract into streamlined, watertight compartments that are built along the top of the sub's hull. The SkyHook program is being jointly developed by British Aerospace and Dowty Boulton Paul of England.

Editor: Dennis Eskow
Contributors: Sheldon M. Gallager,
Terry C. Treadwell, Fran Wenograd
Golden, Ted Francis, William
Blizzard, Steve Eskow

Biper robots walk forward, backward and sideways too.

Marc Raibert's one-legged hopping machine carries a balance rig that moves up and down by compressed air on spring leg.

The Odex from Odetics is the first commercial walking robot.



CONQUERING OUR DEEPEST FRONTIERS

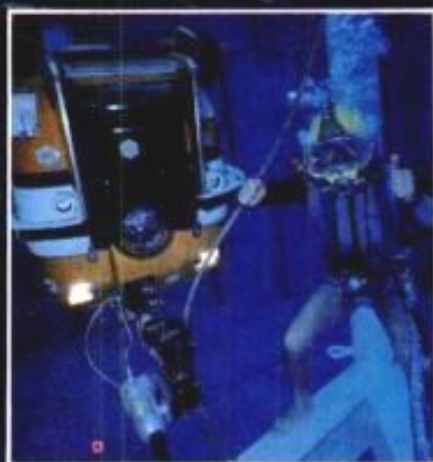
Deep-sea vehicles are taking us deeper than
20,000 feet. And that's where
the treasures lie.



*Sea Shuttle Saga-N lowers
a Remotely Operated
Vehicle to explore and do
salvage work aboard the
sunken *Titanic*. Sea Shuttle
owners are mainly interested
in the nuclear craft's oil
exploration capabilities.*

A technician inside a robot arm-equipped diving suit works with salvage and oil equipment down to 600 feet. Going more than 2,000 feet below him, the one-man *Deep Rover* vehicle performs welding duty. *Deep Rover* carries an array of camera and sensing gear and has a flash lamp that gives its cameras the equivalent capability of 200,000 ASA for sharp sea-floor photos.

BY ALAN SAUNDERS
Illustrated by Jeff Mangiat



Author Alan Saunders joins an unmanned submersible on a 50-foot dive.

With a muffled thud, the aluminum-banded plastic dome of the atmospheric deep-diving suit closed hermetically over my head. I quickly reached out to adjust my oxygen supply, while also glancing at the gauge on the CO₂ scrubber. After that, I checked out the thruster controls as the voice of Dick Clark, the diving supervisor, talked me through the operational checklist over the intercom. The checklist completed, I was ready for my dive.

Clad in borrowed coveralls on a hot May morning in Los Angeles harbor, I was being initiated into the world of the one-man submersible at Oceaneering's Commercial Diving Center, a school for professional divers. It is the only one in the world using Atmospheric Diving Suits (ADS). The suit kept me under normal atmospheric pressure as I descended into the ocean.

Weighing over half a ton and selling for several hundred thousand dollars, it is difficult to think of it as a suit—something to wear—even when going for something as exotic as a deep dive to the ocean bottom.

Wasp, the ADS I took on my first journey, is tethered, has four electric thrusters and an on-board air supply, and operates at close to neutral buoyancy. Like *Jim*, its predecessor, it has two Michelin-man arms through

HOW DEEP IS THE OCEAN?



Two tethered Remotely Operated Vehicles descend beyond 1,000 feet beneath the sea to perform mapping and sensing duties.

which my hands can operate a pair of brutal-looking claws at the ends. With either suit, I can roam the ocean bottom, but *Wasp* with its thrusters will "fly" me through the water, something *Jim* cannot do.

New undersea technologies have handed us the key to Davy Jones's locker and a taste of the fabulous treasures it can hold—oil for our current machinery; the promise of food for an exploding population; new mineral deposits to feed our factories; access to the energy inherent in wind, current, tide, wave and thermal gradient; and last, but certainly not least, the military advantage of hiding, or being able to find, nuclear subs.

Locating anything in the deep ocean is difficult, even when that something is clamoring to be found. Roger Chapman can attest to that. In 1973, he told us, he spent three days trapped in a tiny sub. "We had been laying a transatlantic cable off the Irish coast. On surfacing, while being readied for recovery by our support vessel, a valve on *Pisces III*, our two-man sub, malfunctioned. Suddenly, the aft compartment was flooded. Within seconds the sub, now standing on its tail, began to sink. At 1,575 feet, with a soft sucking sound, she settled on the bottom, still stern first.

"I thought I'd bought it," he continued, "but the pressurized hull held. Trembling, I checked the underwater radio telephone. It still worked. We had contact with the surface."

When the rescue ships arrived, not even the combined might of the U.S., Royal and Irish navies, plus the loud singing of Roger on the radio, could locate the sunken submarine. They could talk to her, but not locate her. It would take six and a half hours, after the arrival of *Pisces V*, a sister ship

DEEPEST DIVE (UNASSISTED)

Jacques Mayol,
282 ft. off
Elba, Italy,
November 1973

DEEPEST DIVE (SCUBA)

John Gruener
and R.N. Watson,
437 ft. off
Freeport, Bahamas,
October 1968

DEEPEST DESCENT OF A DIVING BELL

Cornex MOB 1001/1002,
1,370 ft. off
French coast,
January 1977

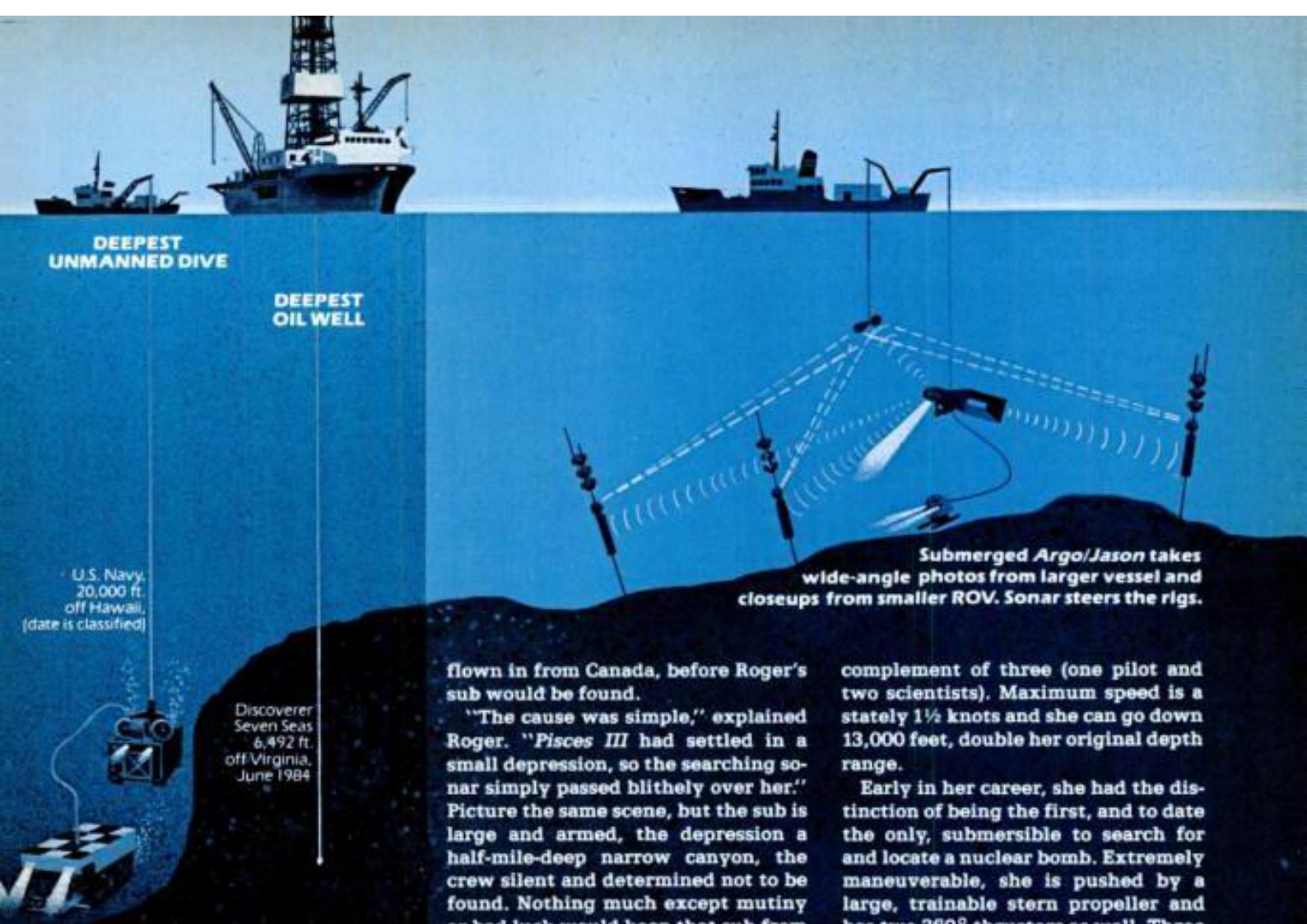
DEEPEST DESCENT OF A HUMAN-CARRYING VESSEL

Trieste I,
35,820 ft.
off Guam,
January 1960

DEEPEST OCEAN POINT

35,820 ft.
(in dispute)





DEEPEST UNMANNED DIVE

DEEPEST OIL WELL

U.S. Navy,
20,000 ft.
off Hawaii,
(date is classified)

Discoverer
Seven Seas
6,492 ft.
off Virginia,
June 1984

We know how high the sky is, because we've traveled into space. But how deep is the ocean? Many geologists agree that the deepest part of the ocean was discovered in 1960 when the U.S. Navy research sub Trieste I landed in the Marianas Trench off Guam in the Pacific. Some oceanographers think we may find a sea rift in the Pacific that goes deeper, but for now it's just speculation.

The deepest unassisted human dive was made by Italy's Enzo Maiorca off Sorrento in 1974. But he surfaced unconscious, so the official record goes to France's Jacques Mayol, who dove 282 feet off Elba in 1973. That was 1 foot less than Maiorca's dive. (Duke University physiologist Richard Vann says the deepest dive recommended for a healthy human should be no more than 130 feet, if the diver has an air supply.)

The deepest diving bell dive was performed in the French Comex MOB 1001/1002 in 1977. But unmanned diving rigs have gone 20,000 feet below the surface. And many rigs with robot arms are performing salvage work at more than 5,000-foot depths today.—Fran Wenograd Golden

flown in from Canada, before Roger's sub would be found.

"The cause was simple," explained Roger. "Pisces III had settled in a small depression, so the searching sonar simply passed blithely over her." Picture the same scene, but the sub is large and armed, the depression a half-mile-deep narrow canyon, the crew silent and determined not to be found. Nothing much except mutiny or bad luck would keep that sub from firing its warheads if it wanted to.

Except as war machines, manned submersibles had been of little use to mankind until the 1930s. Then, a daring American bathyscaph with William Beebe aboard made a half-mile dive. With that dive, the deep frontier was breached. Thirty years later in rapid succession, Trieste, another bathyscaph, manned by Jacques Piccard and Don Walsh, would plunge 35,800 feet into the Marianas Trench, the deepest point in the ocean floor. And Triton, a U.S. nuclear-powered submarine, would circumnavigate the globe under water. Depth and distance had been conquered.

It would now fall to others to fill the gaps between surface and deep bottom, between knowledge and myth. Two names leap up from a most distinguished roster: Alvin, a submersible, and Jacques Cousteau, the self-proclaimed man-fish. While Alvin would make scientific history, it was Cousteau who, with his love and understanding of the ocean, would bring that history to life.

Alvin, like nearly all scientific subs, is owned by the Navy and operated by academia—in this case, the Woods Hole Oceanographic Institution. Built in 1964, she is fat, squat, 25 feet long and displaces 16 tons. She can stay submerged for 72 hours with a full

complement of three (one pilot and two scientists). Maximum speed is a stately 1½ knots and she can go down 13,000 feet, double her original depth range.

Early in her career, she had the distinction of being the first, and to date the only, submersible to search for and locate a nuclear bomb. Extremely maneuverable, she is pushed by a large, trainable stern propeller and has two 360° thrusters as well. Three 5-inch viewports allow direct observation of the outside world, while two manipulator arms can gather samples, place instruments and perform other tasks.

Alvin's big moment came in 1977 while exploring the Galapagos Rift off Ecuador. Coming upon a cluster of hy-

Submerged Argo/Jason takes wide-angle photos from larger vessel and closeups from smaller ROV. Sonar steers the rigs.



The ROV Epaulard is prepared for a dive to 20,000 feet from International Underwater Contractors' ship Aloha.

JANUARY 1985 \$1.50

Popular Mechanics

Step-By-Step
Build Cabinet
Doors Like
A Craftsman



NEW SUBS That Carry Men Miles Under The Sea

SNEAK PREVIEW

4 American
Sports Cars
From European
Stylists

FLYING FORTRESS

50-Year-Old
Warplane Still
Packs A Wallop

PLANS: Make Our
6 Solid-Maple
Home Accessories

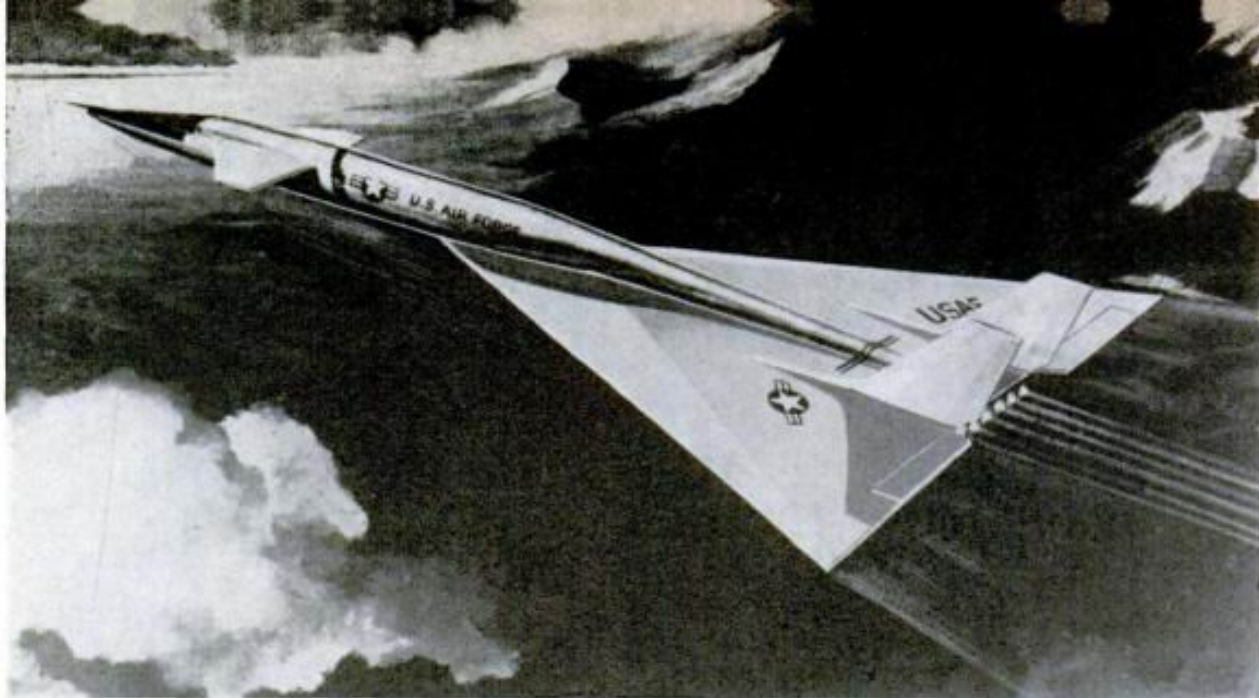
EXCLUSIVE: Russia's
New Space Shuttle

SNOW-TIRE GUIDE
PM Tells You Exactly
What They'll Do For You



Deep Rover
'Flies' Underwater
Like A Helicopter





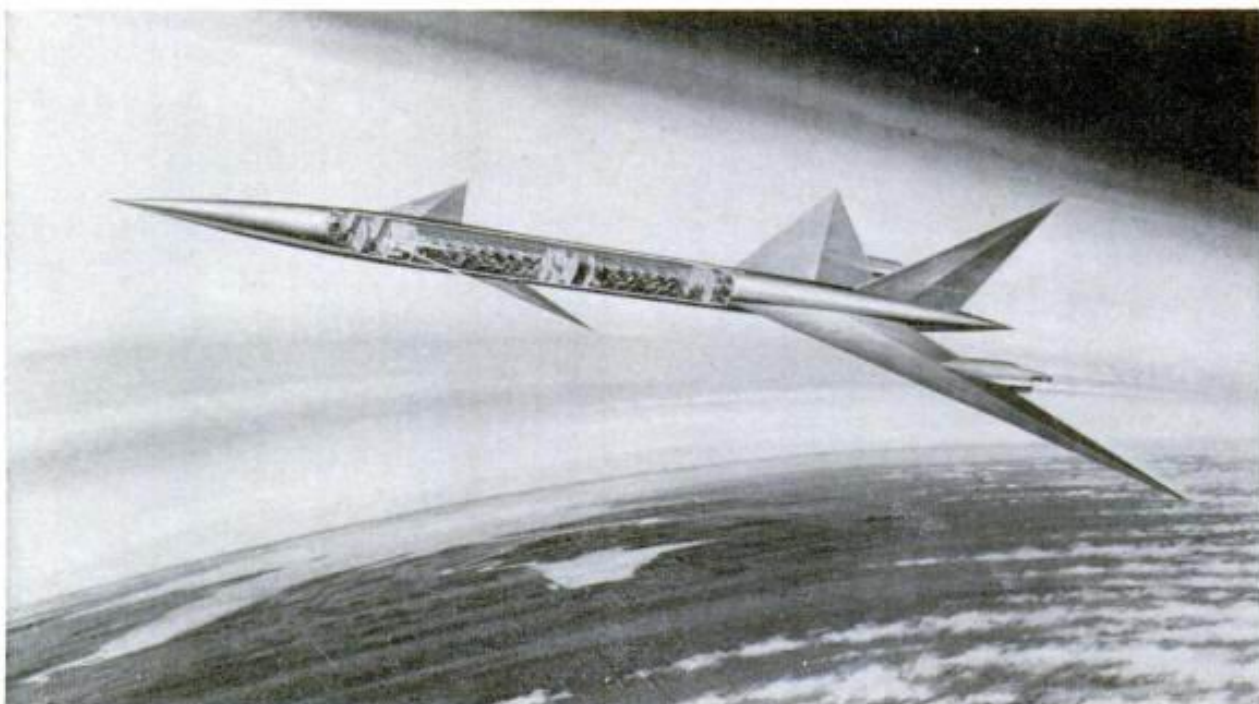
Here's a Peek at Tomorrow's Huge Planes

TWO aircraft companies are taking first steps to introduce faster-than-sound, large-sized commercial and military airplanes within the coming decade. North American Aviation, Inc., is building a prototype of the B-70 intercontinental bomber (above). Lockheed Aircraft Corp. is advocating a 2000-mile-per-hour transport adaptable for use as a military tanker, and has suggested a possible design (below) as well as an estimate of production costs.

The B-70 will feature a supersonic survival seat for each of the four crew members. Constructed like a capsule, it is sealed so there is no need for the men to wear oxygen masks or pressurized flying suits. In an emergency, at near-vacuum heights above 70,000 feet, for example, the

seat will rocket from the plane and be lowered by a 34-foot parachute. It will function as a boat should it land in water, and will carry 45 pounds of survival gear, giving protection against cold and heat.

Lockheed officials, arguing there is now no technical, operational or economic reason why a supersonic transport could not be developed in the U. S., suggest that its shape could be needle-pointed fore and aft, and that it have a swept-back stabilizer near the front of the fuselage. Passengers would sit forward of the delta wing. Such a 250,000-pound steel airliner would cost some \$160,000,000 to develop, according to Vice-President Burt C. Monesmith. He estimates that in quantities of 200 the planes could be built for \$9,240,000 each.





COMING:

The Fastest Train In The West

At 160 mph, these Bullets will take you from Los Angeles to San Diego in less than an hour.

BY DENNIS ESKOW, Science Editor; Illustrated by Willardson & White



The sleek, silvery machine bombs down the roadbed at a hot 160 mph, leaving the nearby freeway traffic in its dust. It speeds along railroad tracks, but the noise it makes is closer to the buzz of a gliding speedboat than the din of a fast-moving railroad train. It's the California Bullet, flying down the Amtrak corridor from Los Angeles to San Diego in 59 minutes. The fastest train in America operates only on paper today, but it's slated to become a \$3 billion reality by the Fourth of July in 1987.

"We want to get off to a smooth start, so we're going to rely almost entirely on established Japanese technologies," says Nick Brand, director of planning for American High Speed Rail, the company that will operate the nation's first bullet train. Japanese and French bullets have been running at speeds of over 140 mph since the 1970s, but noth-

ing rolling on American rails has even come close.

The California Bullet operators have already completed studies of the Santa Fe railroad trackbed that will carry 100 trains a day between Los Angeles International Airport, downtown Los Angeles and downtown San Diego. Late next month, the rail company will submit an environmental impact statement to the California Environmental Protection Agency. And, before year's end, contracts will be awarded to several firms for building trains, laying special high-speed track and digging a series of tunnels to take the Bullet through Southern California's mountains.

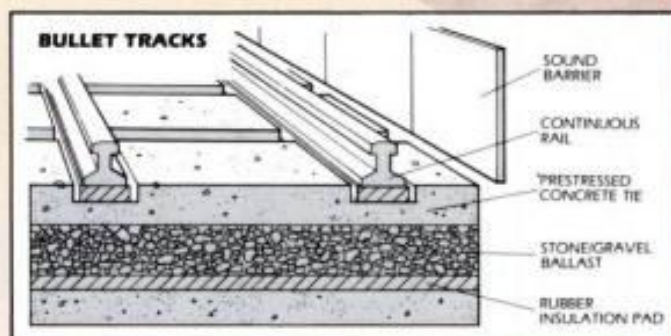
Whether it's built in America or Japan, the first American bullet will use Japanese motors and power-collection systems. Two locomotives—one at the front and one at the rear—will power 8 to 10 cars. The



locomotives house the train's power transformer, converting d.c. power supplied by an overhead wire to a.c. power for distribution to the individually powered axles.

"We'll tap into the Southern California power grid's 250-kv. lines for our energy," says Brand, adding that the train will need several substations along the way to transform the utility's power to 25 kv.

The interiors of the trains will differ greatly from their Japanese counterparts. The American version will have fewer seats per car in an attempt to provide legroom and traveling comfort. The line operators expect to attract 100,000 passengers a day by 1988, the first year



Artist's conception of first American bullet (above) is streamlined and low to the special track joined by prestressed concrete ties (left). Another concept shown on PM's cover would have upper and lower compartments. All proposed American bullets would run power from the locomotive to motorized axles on each car.

of full operation. In addition to luxury seating, the American trains will include a bar car.

The outer shell of the American bullet will be far sleeker than the original. "The Japanese train goes through snowy territory," explains Roger Ansbarger, consulting engineer to the U.S. Department of Transportation. "A high-speed train in California wouldn't need a snowplow in the front, so it could be more aerodynamic."

Traveling at average speeds of about 140 mph, the California Bullet will use

special tracks with prestressed concrete ties atop stone and gravel ballast, supported by a rubber insulation pad on concrete. To lay down the new track, American High Speed Rail will take up most of the current Santa Fe railroad 100-foot right-of-way. The present tracks support trains with top speeds about half that of the Bullet and use about 20 feet of right-of-way.

Digging tunnels at mountain locations in the La Jolla and San Clemente areas is about the lowest-tech item on the rail company's list of priorities.



A Japanese bullet makes a stop at a station in Tokyo. American models will be sleeker.

PM EXPERIENCE: Riding The French Bullet



France's TGV bullet reaches speeds of up to 165 mph. The motorman goes along for the ride since the train is controlled by microprocessors in the tracks.

If you're going to ride France's *Tres Grande Vitesse* (very high speed) train, get one northbound from Lyon or—even better—from farther south. Boarding at Marseille or Avignon, you'll twist along the Rhone River at merely 80 to 90 mph. Heck, that's Amtrak stuff. But once Lyon has drifted by, things begin to happen.

At Sathonay, a northern suburb of Lyon, the TGV shunts onto its own roadbed. Assuming the interval is correct, as monitored by the TGV central command post 240 miles away in Paris, the *mecanicien* (engineer) gets an authorization to increase his speed. He'll get either a direct digital indication of the maximum, 165 mph, or one of several intermediate steps.

The engineer is alone in the cab. If he doesn't respond to the changing digital inputs on his panel within seconds, the train can be brought to a stop automatically. These signals are fed through the tracks, changing every

1,700 meters as the train enters a new electrical "canton" (discrete circuit).

Even at relatively low speed, the smoothness of the roadbed, heavily ballasted with concrete ties, is apparent—and welcome. Before we know it, we are hitting 165 mph, or better.

Yet it all seems so... conventional. Water, or whatever you're drinking, sits level in the glass on your seat tray.

The standard TGV unit—eight cars with locomotive power at each end totaling about 8,500 hp—could routinely operate at speeds near 200 mph.

Non-French planners were prone to call the \$1.5 billion TGV system, including road-

bed acquired and built at the cost of \$4 million per mile, an "extravagance" when it was first announced. Now, as passenger revenues run far ahead of projections, they are silent. This fall, the final 65-mile stage on the Paris-Lyon high-speed line will open, further cutting what was in 1980 a 3-hour, 50-minute trip to two hours flat.

—Robin Nelson

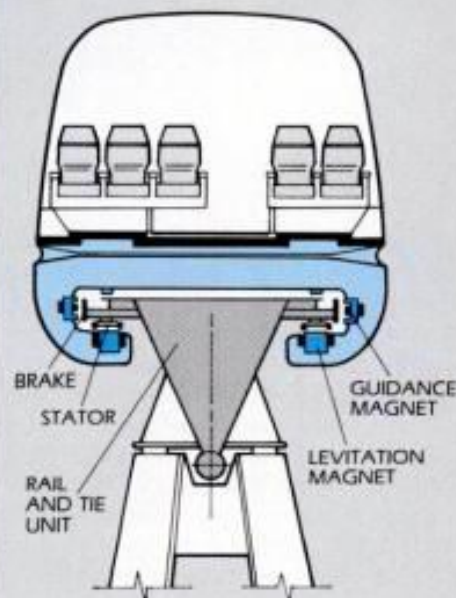


The smooth *Tres Grande Vitesse* offers first-class comfort, including bar car.

This past summer, West Germany's "maglev" train—two sleek, cream-and green-colored cars accommodating 196 passengers in first-class jetliner comfort—began zipping along at speeds of over 200 mph on a specially built 20-mile test track between the villages of Lathen and Doerpen in northern Germany.

The "Transrapid-06" vehicle is 178 feet long, 12 feet wide, 10 feet high and weighs an astonishing 224,000 pounds, every ounce of which is kept afloat over the track edge by 64 powerful levitating and 56 guiding electromagnets. When it moves, the only sound inside is a faint, pleasant hum.

However, a reduction in funding by the West German railroad authority may prevent this maglev from getting beyond the trial-run stage. But if the technology "flies" over the next year



The maglev's upward-pointing "longitudinal flux magnets" make the vehicle rise above the tracks. These magnets lift the train with a force of nearly 1.8 tons per magnet. Guiding magnets at the sides of each car pull the train along the special rail at speeds of up to 200 mph. Maglev trains may be in the United States by the 1990s.

"The rock is so soft you can mine it like a coal mine," Brand explains. "Work can start less than two years before we begin operation."

High-speed railroading is potentially the wave of the future in American intercity travel. With an undisclosed amount of cash from Japanese backers, the California enterprise received a stateside boost last summer when the First Boston Co. announced it will help arrange backing from American investors. Meanwhile, the California company has plans on the drawing boards to

build high-speed systems linking Houston and Dallas and perhaps Miami and Orlando, Fla., by the end of the century. On a similar note, the U.S. Department of Transportation is studying a possible maglev high-speed system to connect Los Angeles with Las Vegas.

"We hope to contribute to a revival of the rail-car-building business in America," Brand says. "Japanese technology is just a starting point. I can see American aviation manufacturers and others providing concepts for second-generation bullet trains."



American bullet will have a two-man cockpit like its Japanese forerunner shown here.

WILL MAGLEV FLY?

and a half, maglev trains may be operating in the United States by the 1990s.

Transrapid is the result of 13 years of development by a West German consortium. The current testing calls for 18 hours of daily commuter operation under all kinds of weather conditions and temperatures. "I've been waiting for this moment for almost five years," gushed Günter Steinmetz, chief of the project. "Of late, we Germans have fallen behind in the high-technology race. But for the first time people will not be saying that we've 'reinvented the wheel.' In fact, we've abolished it." This past spring, the operational Transrapid was rolled out onto a guideway that is entirely elevated, set on airy, concrete pylons so that the vehicle operates 16 to 20 feet above the ground.

The U.S. Department of Transportation has already approved the Transrapid as the basic vehicle for a proposed 8,800 passenger-a-day Los Angeles to Las Vegas connection. That system is still in the conceptual stage, but federal officials have said that the Transrapid's success could lead to funding for the American version.

Though Transrapid is slower than its Japanese competition—whose experimental vehicles have hit more than 320 mph over very short hauls—the German electromagnetic technology is less complicated. Transrapid, for example, does not require the vestigial wheels that the Japanese vehicle needs when resting and starting up.

"Levitation is as simple as using a toy magnet," said Peter Wurm, a consortium engineer. He compares the system



Transrapid guideway is elevated 16 to 20 feet above ground on concrete pylons.

to a three-phase synchronous electric motor. The stator, which provides the energy that turns the rotor, is laid out in the track. The rotor, that part of any electric motor which actually moves, is the train itself. Even the power source is conventional, drawn from a 110-kilovolt high-tension line.

Each of the two cars has 60 magnets painted bright red, measuring 59 inches long and about 12 inches square. They are held in place within the bogies by hinges and powerful primary springs. Thirty-two of the magnets, 16 on each side of each car, are mounted horizontally so that they point up to the underside of the track where the iron-cored stator packs are located. These are the longitudinal flux magnets that levitate the vehicle, lifting it up toward the stator packs in the track with a force of nearly 1.8 tons per magnet. The other 28 magnets, 14 on each side of the car, with a magnetic flux perpendicular to the track, serve to guide the train.

The trial program will check the general performance of the vehicle under simulated long-distance conditions. The program will also examine the viability of the track, as well as other factors.

"Everything now depends on these trials," said Gert von Lieres of the West German consortium. "But we are confident that by the mid-1980s, Transrapid will have proven itself."

—John Dornberg



Side view of Transrapid shows guiding magnets that keep the 178-foot-long train on its forward run. Each car has a total of 60 magnets. Power is from a 110-kilovolt line.

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The
California
Bullet
Highballs
At 165 MPH



Round-Robin Rocket

HUNTINGTON BEACH, CA—The single-stage-to-orbit, reusable spacecraft commissioned by the Strategic Defense Initiative Office (see *Tech Update*, page 9, July '91) won't be a spaceplane. Instead, it'll be the Delta Clipper, a wingless cone designed by McDonnell Douglas. The craft will rocket into orbit vertically, reenter the atmosphere nose first, then use flaps and differential throttling on its eight engines to flip around. Engines will fire at 25% thrust to cushion its landing. Vertical touchdown will allow the

spacecraft to land within a 50-ft. radius. The Clipper will lift payloads of up to 20,000 pounds.

Supporting the rocket's repeat performances are simple on-board systems, such as a giant spring for deploying payloads. They'll keep launch costs down to \$600 per pound, says McDonnell Douglas.

A 1/3-scale demonstrator called the DC-X will fly in 1993 at White Sands Missile Range.

Delta Clipper will feature quick turnaround, readied for launch in less than a week.



MCDONNELL DOUGLAS ILLUSTRATION

Train Technology Rolls Into Texas



GEC ALSTHOM PHOTO

HOUSTON, TX—While flagging economies have derailed several high-tech train ventures across the country, the Lone Star State has attracted two state-of-the-art rail systems.

Texas has granted makers of France's TGV—the world's fastest locomotive—a franchise to build a line linking

Houston, Dallas/Fort Worth and San Antonio. The TGV consortium beat out a rival offering Fastrac, based on Germany's Inter City Experimental, which has seen only limited service.

Bombardier will supply the rolling stock, while Morrison-Knudsen will engineer and build the tracks. The flat Texas plains are a natural for the TGV, which relies on a dead-straight track to build up a speed of 186 mph.

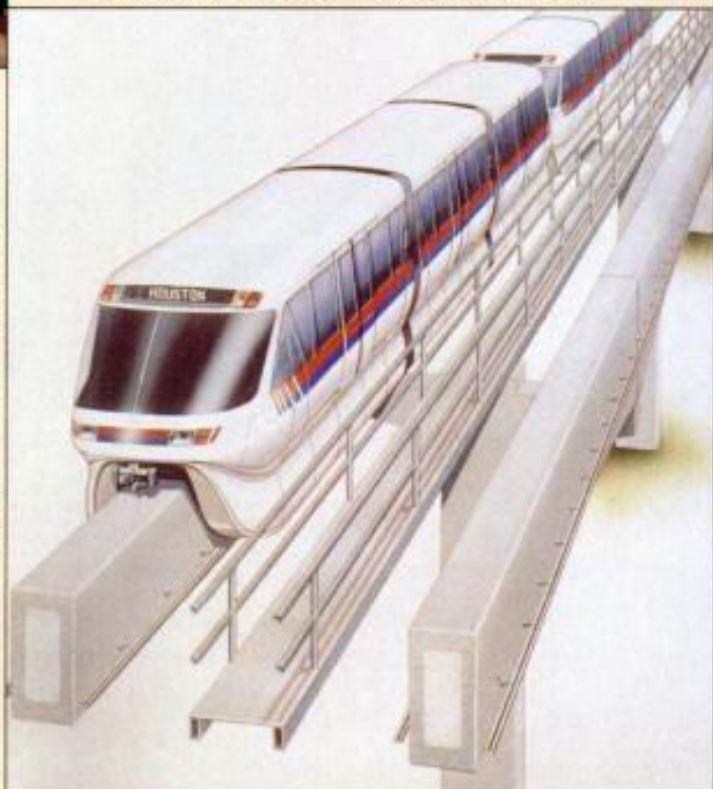
TGV (above) will cross Texas at 186 mph. Disney-style monorails (right) will be Houston's light-rail system, with mass-transit interiors (left).

A planned 220-mph TGV may be ready for the Texas project.

Meanwhile, Houston has asked Bombardier to start preliminary engineering studies on the nation's first mass-transit monorail system. The city's plans call for two lines, covering 20 miles, that carry urban versions of the Mark VI straddle-beam monorail operating at Disney World. Single cars carrying 160 pas-

sengers will run independently and hook up into triplicate platoons during rush hours.

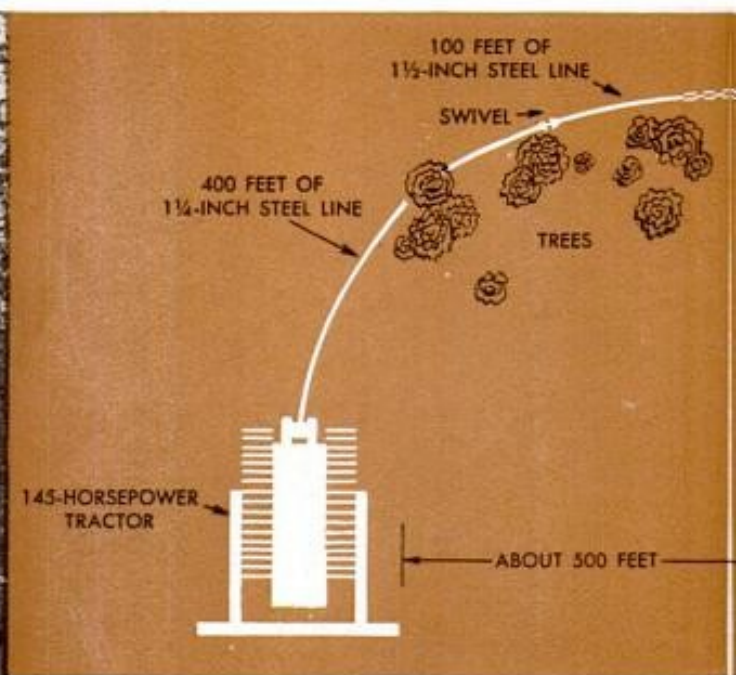
Much of the system will scoot along overhead concrete beams, although a short monorail subway section may serve downtown Houston. Construction is expected to begin in 1993. Kiewit Construction has paired up with Bombardier on the project, and the team is competing to build a similar system in Honolulu.



TGV ILLUSTRATIONS



Big steel ball holds line off ground during mowing operation to avoid stumps of large trees logged out



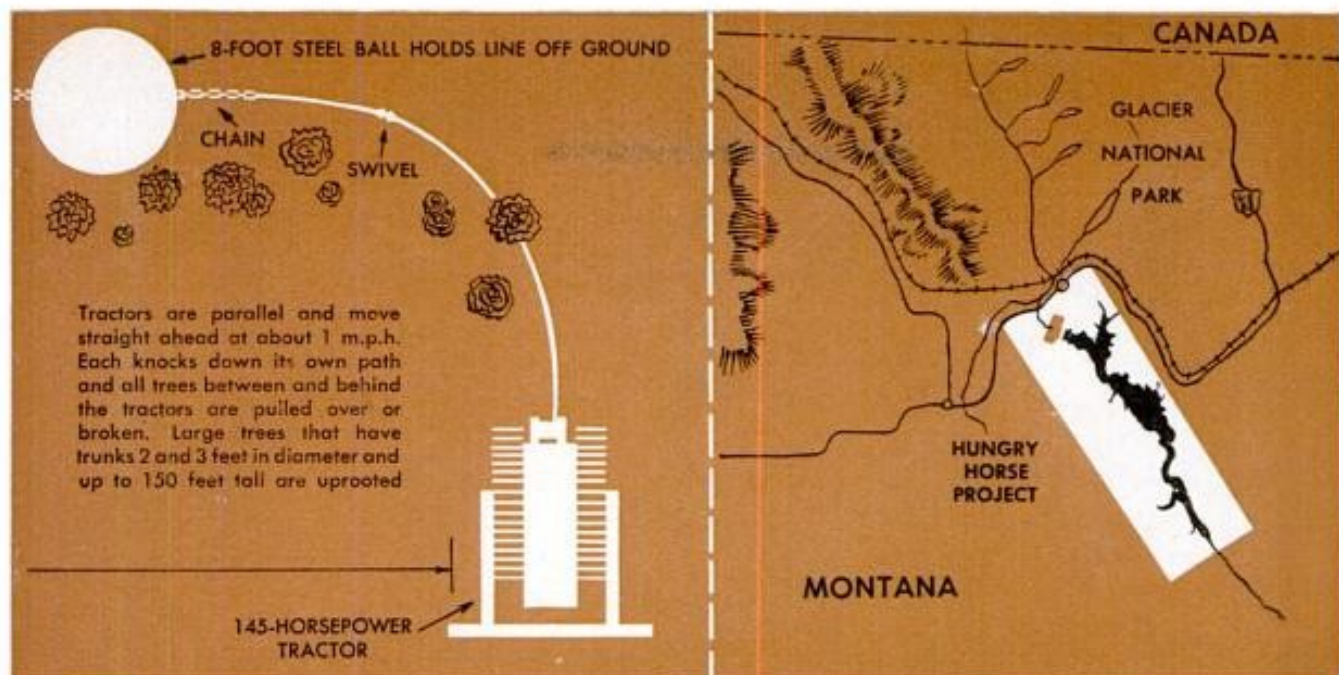
“Bowling” Down

MOW DOWN a forest like it was a field of wheat? Not even the legendary Paul Bunyan could do that.

But wait—up in northern Montana a couple of ingenious engineer-contractors have built mowing machines that slash through timber just the way a threshing machine moves through a grain field. Trees 100 and 150 feet tall topple over like straws. Between breakfast and lunch two men and their equipment can mow down as much as 100 acres of virgin forest. Then the clanking, roaring “stacking cats” move in

Trees fall like tenpins as tractors pull the steel line through the forest. The steel ball is behind trees





Forests for a Super Dam

and rake the fallen trees into windrows.

These Gargantuan operations are taking place in the reservoir area back of Hungry Horse Dam which, when completed in 1953, will be the fourth largest concrete dam in the world. The reservoir site is 34 miles long and up to 3½ miles wide, some 35 square miles in all. Before the clearing operations began it was covered with a thick forest of pine, fir, larch and spruce.

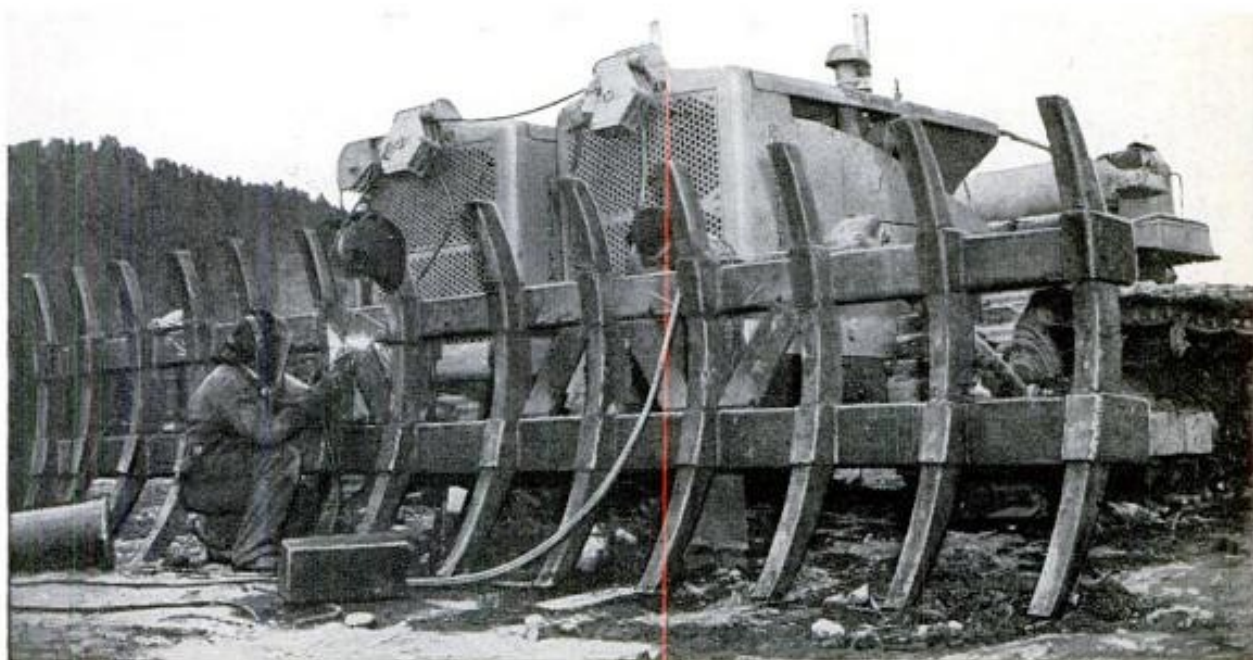
The area contained 80,000,000 board feet of merchantable timber and the first task was to log these trees, saw them up and haul the lumber out. This left hardly a dent in the thick forest.

Every tree that remains, almost every

twig, must be removed and the ground scraped clean before the site can be used as a reservoir. Otherwise trunks and limbs would be floated by the rising water and would drift down and clog the debris booms and the trash racks that will guard the intakes of the 285,000-kilowatt powerhouse.

When the Bureau of Reclamation asked for bids for removing the first portions of the 25,000 acres of forest, smart engineers from as far away as Louisiana and California tried to figure out the cheapest way of clearing the trees.

Twin rig for clearing away fallen trees is made of two tractors that push a 21-foot rake with 13 teeth



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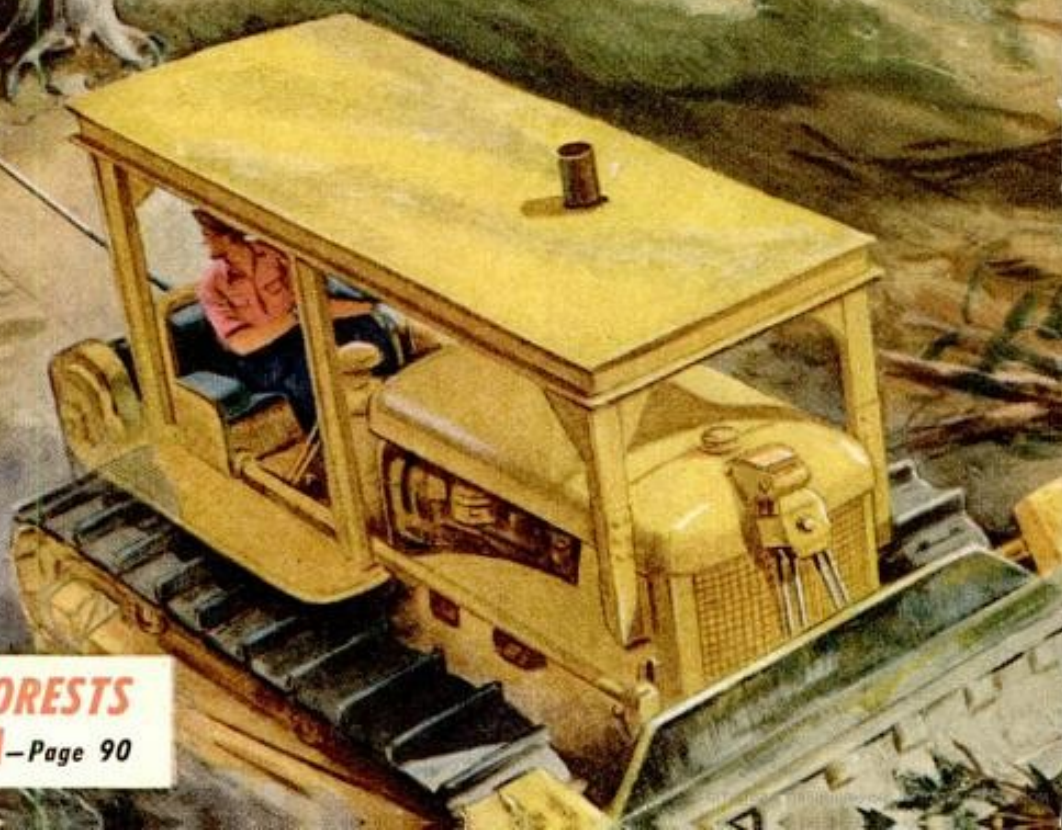


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**"BOWLING" DOWN FORESTS
FOR A SUPER DAM**—Page 90

How to Get—and Tell—a Good Body-Repair Job

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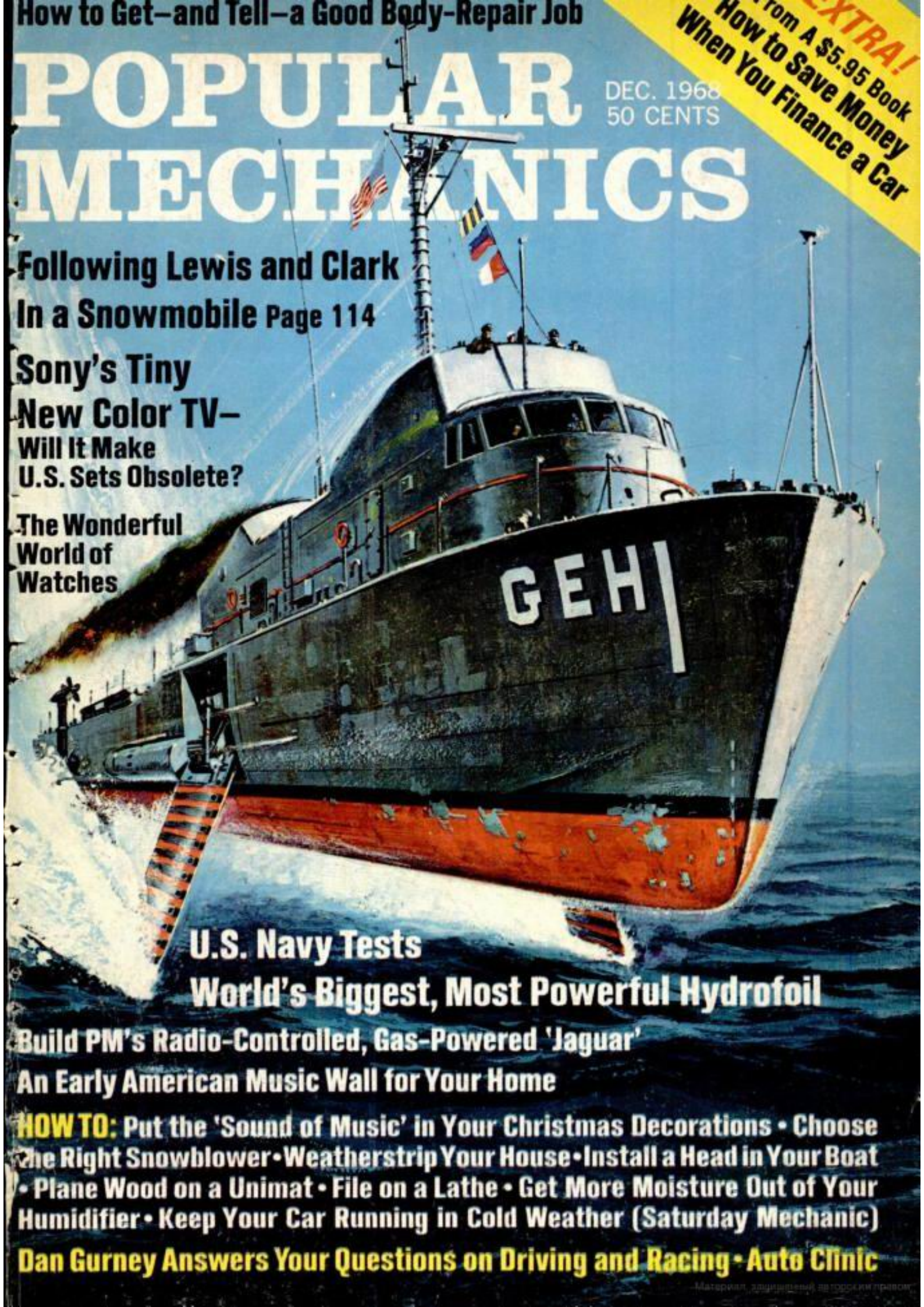
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The Biggest, Fastest

It's 212 feet long and displaces 300 tons, but when it goes up on "stilts" it skims across the water — even heavy seas — at better than 40 knots. It's the Navy's latest in a new breed of hydrofoils.

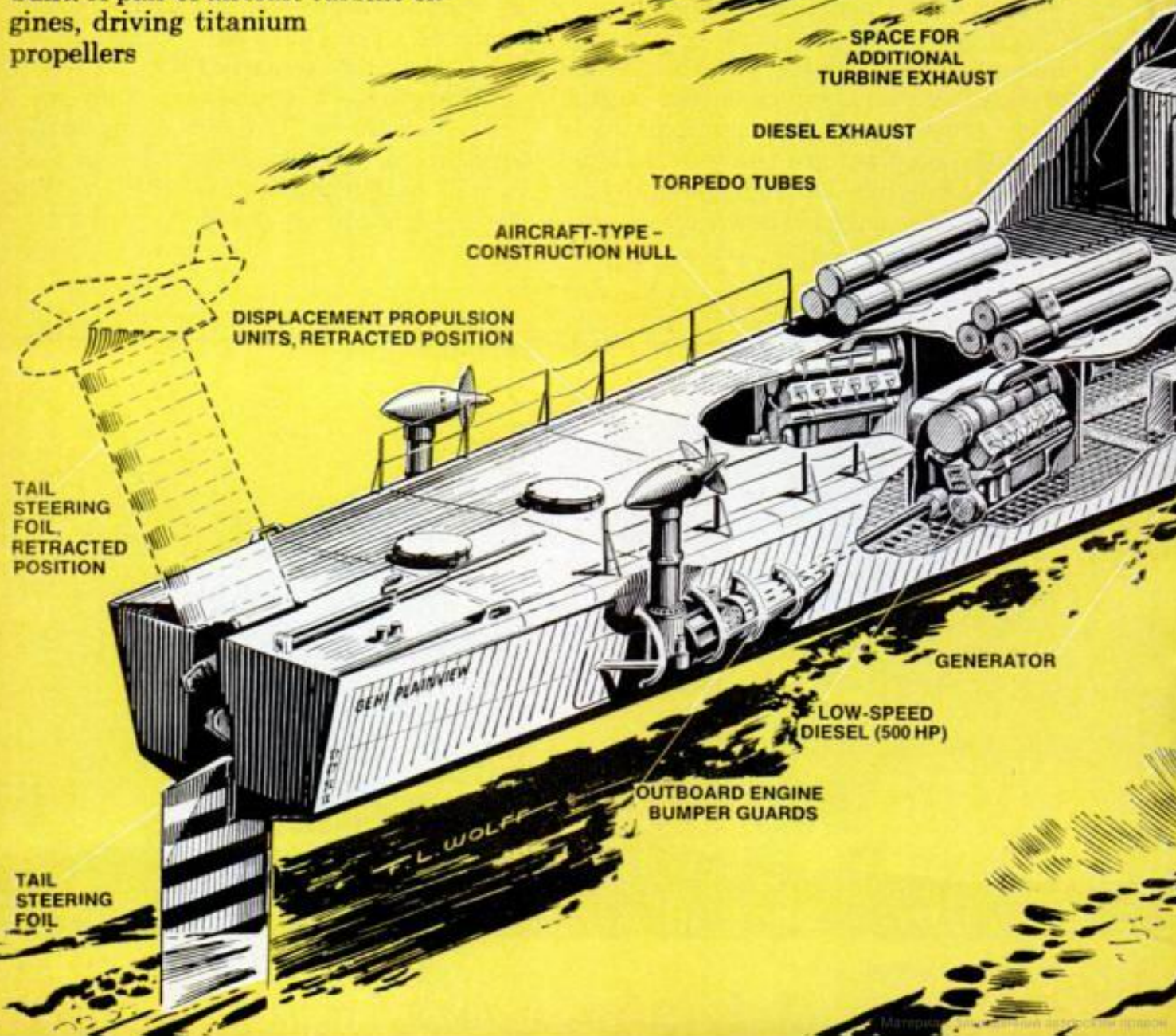
By BOB ZIMMERMAN

Technical Art Concept by Fred Wolff

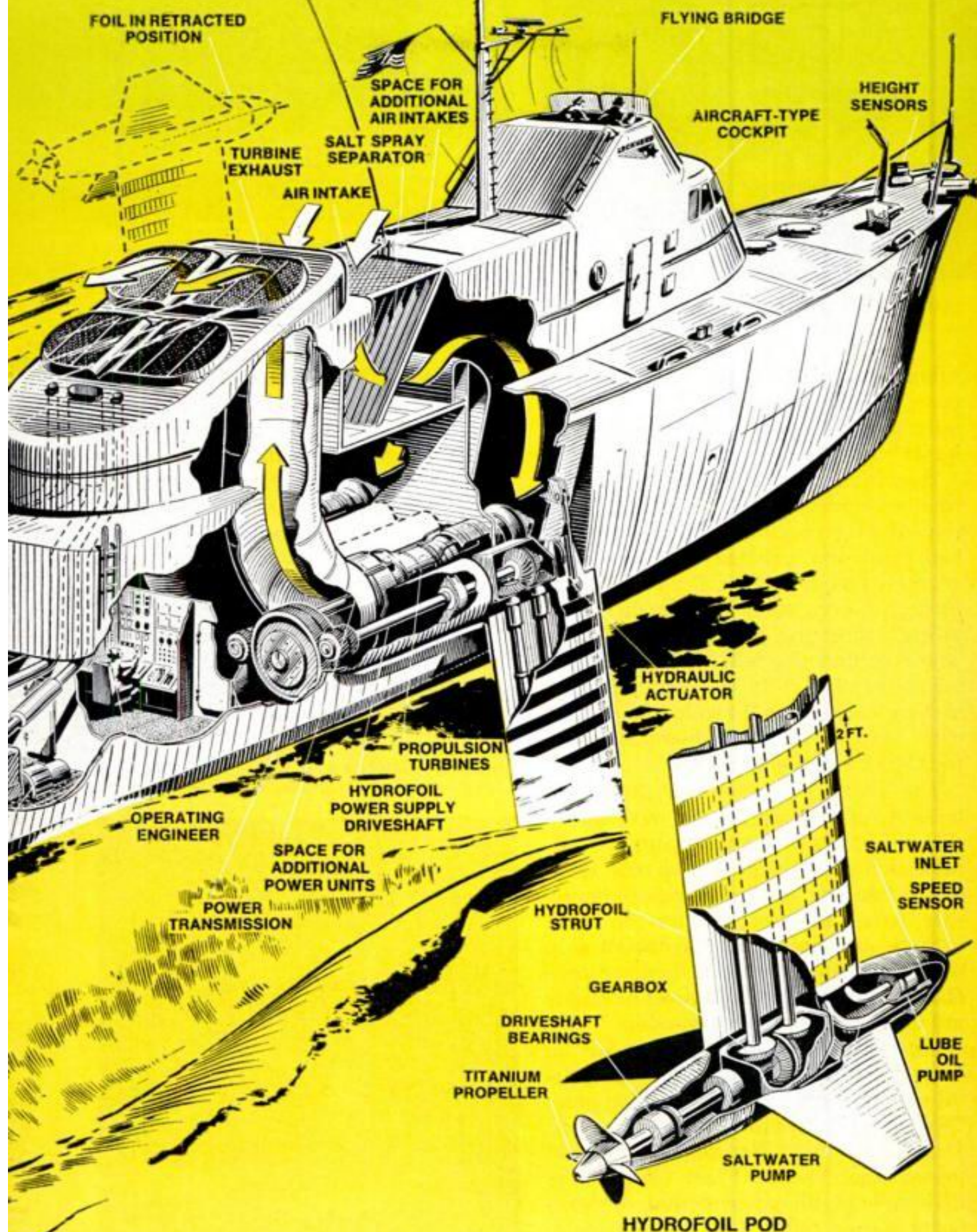
PICTURE A DESTROYER bristling with guns and torpedo launchers skimming at 50 knots or more over the surface of a stormy sea. You can see daylight under the hull. The ship is flying — literally. Its wings are hydrofoils, knifing through the water on struts.

An admiral's pipe dream? Not quite. The new USS *Plainview*, just beginning a test program with the Navy, may be the forerunner of a fleet of such high-flying sub-chasers.

The *Plainview* — 212 feet long and displacing 300 tons — is the largest hydrofoil ship ever built. A pair of aircraft turbine engines, driving titanium propellers



'Flying' Boat Yet!





PLAINVIEW'S COCKPIT looks like jetliner's, and men in charge are known as "pilot" and "co-pilot"

submerged along with its foils, can push the ship to what the Navy modestly says is a speed "in excess of 40 knots."

How much in excess is classified. But smaller hydrofoil craft have already proved that speed possibilities on the high seas are greater than mariners ever imagined. Hydrofoil boats can hit 65 mph before their foils begin "cavitating" (creating an air cavity in the water behind the foil), a limit of performance similar to the sound barrier met by conventional airplanes. A craft with experimental "supercavitating" foils has been clocked at 80!

The *Plainview*, made by the Lockheed Aircraft Corp., is the most ambitious effort yet to put oceangoing vessels into such speed ranges and free them of the bucking and buffeting of choppy seas. It will be a test bed for the Navy to find out how such a hydrofoil ship will handle in all weather and sea conditions and how it would meet demands put on an active modern warship.

This aluminum-hulled wonder is only one blossom on a suddenly fruitful vine of Navy hydrofoil development. Two new hydrofoil gunboats, named *Tucumcari* and *Flagstaff*, have just joined the Pacific Fleet. While the *Plainview* is still experimental, the gunboats are full-fledged combatants. They are scheduled for combat trials to



RESTING PLAINVIEW gives some indication of its size (note crewmen amidships). Three hydrofoils, two

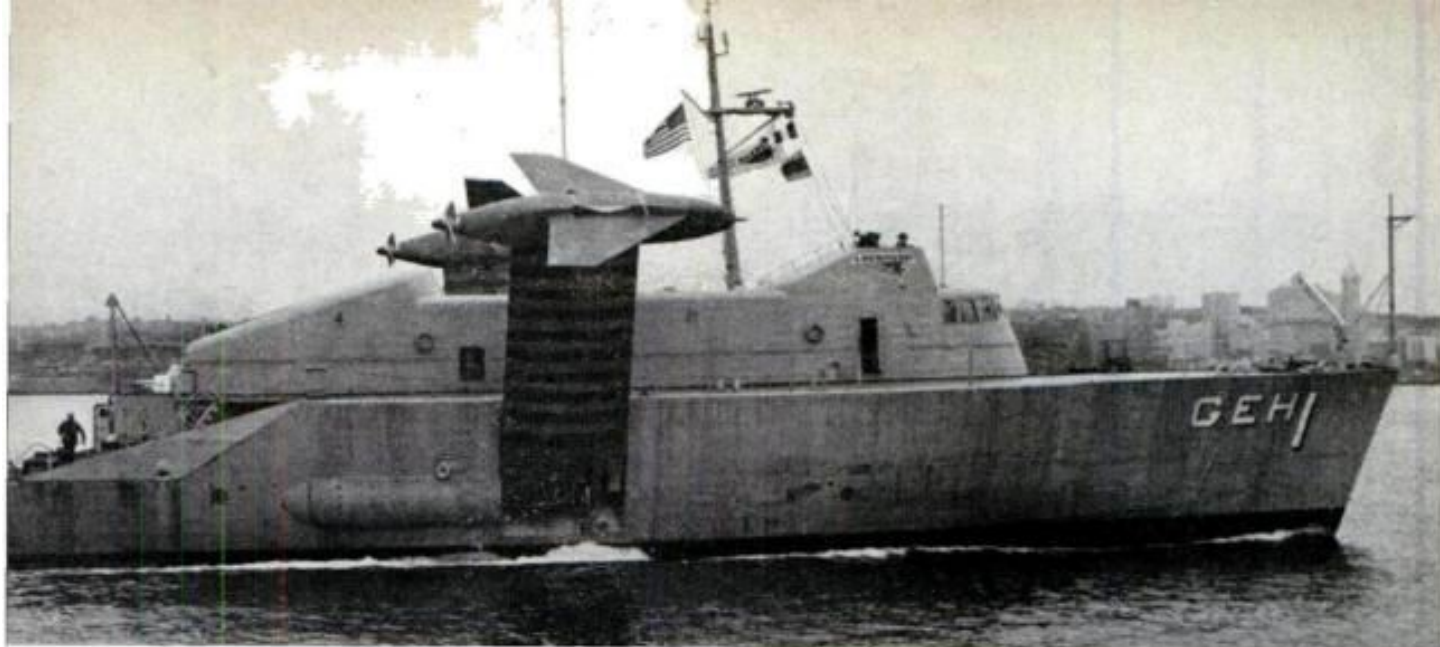
take place off the coast of California.

The principle of hydrofoils is simple enough: They use the water as a medium of flight the same way airplanes use the air. Hydrofoils are winglike surfaces mounted on struts under the hull of a boat or ship. They look like airplane wings and have the same cross section—a curved upper surface and a flat lower surface. Water flowing over and under the hydrofoil produces lift the same way an air current does.

Arrival of the huge *Plainview* on the scene means hydrofoil technology is

GUNBOAT TUCUMCARI, built by Boeing, features canard configuration, with one foil forward, two aft





forward and one aft, are in retracted position, displaying their winglike construction. *Plainview*, the largest hydrofoil ever built, is 212 feet long, displaces 300 tons and is intended to perform the duties of a destroyer

well out of the nursery and into long pants.

The world inhabited by the *Plainview* crewmen—it takes 20 to run the ship—is a strange blend of forecastle and flight line. The ship's wheelhouse, if that's the word, looks more like the cockpit of a jet airliner. The "pilot" and "co-pilot" are surrounded by instrument panels—overhead, in front and between seats. In the engine room are two marine-type J-79 jet engines, the same kind used in the supersonic F-104 Starfighter.

GUNBOAT FLAGSTAFF, built by Grumman, has conventional configuration, two foils forward, one aft



Actually, the *Plainview* has two powerplants. To taxi away from a pier through a crowded harbor, with foils retracted, it is driven by two 600-hp General Motors diesels. Power goes to two outboard propellers mounted on swivels on either side of the hull about 50 feet from the stern. Propeller pods can be turned left and right to steer the ship.

In this configuration, the *Plainview* is a slow, gawky, flightless bird, its forward struts and foils raised out of the water like clipped wings, its stern strut and foil sticking up like a tail.

For flying, the struts go into the water and the diesel propeller units lift out. Then the *Plainview* can run up its turbines, preparing for takeoff.

Power from the turbines is transmitted through an intricate system of gears and shafts to the four-bladed, 62-inch titanium propellers submerged at the tip of the two forward struts. These same struts carry the ship's main foils, each with a "wingspan" of 26 feet.

Takeoff speed is about 30 knots. "If you're down in the hull," says a hydrofoil crewman, "you hear a gurgling sound, and in 20 or 30 seconds you're foilborne."

As if at the command of a magician the *Plainview's* 300 tons rise gently

(Please turn to page 210)

How to Handle the Deadly Hazards of Night Driving

POPULAR MECHANICS

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What V
Owners
Think
of the
New Beetle

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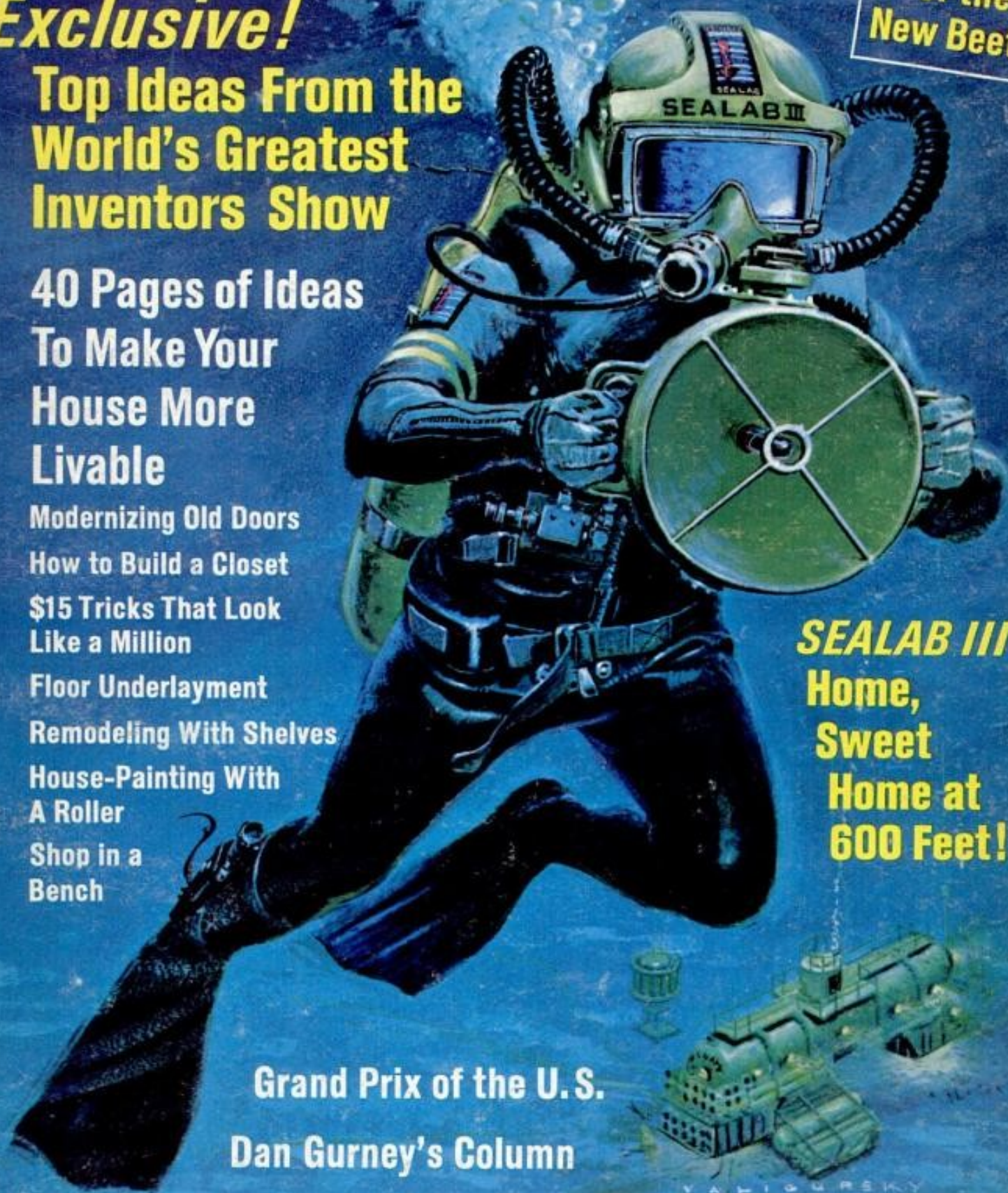
Shop in a
Bench

**SEALAB III
Home,
Sweet
Home at
600 Feet!**

Grand Prix of the U.S.

Dan Gurney's Column

SATURDAY MECHANIC: Installing Real Gauges • Auto Clinic



A LONGER, DEEPER, DARING QUEST FOR THE SECRETS OF LIVING IN THE SEA

This Fall the Navy's **SEALAB III** project will send five teams of aquanauts 600 feet deep—for a total of 60 days—to find: How long can man live and work effectively in the depths of the ocean? □ By Hans Fantel

"LOWER AWAY!" When that command rings out off California's San Clemente Island this fall, it will mark the beginning of man's boldest foray into the last unknown region on this planet. Gushing and gurgling from filling ballast tanks, the Navy's Sealab III will drop from sight and slowly sink to the bottom of the Pacific Ocean. Like the earlier Sealab I and II, the new Sealab III is a kind of ocean-floor hotel and research laboratory. Its two-room interior is crammed with bunks,





Telephone

Oxygen makeup system

Emergency bell

Stowage

TV monitor

Benthic trunk
for air hoses

Power hoist

TV camera

Viewing port

LABORATORY AREA

Figure-eight cable
attachments

Aft hatch

Hoist

DIVERS' STATION

Workbench

Concrete deck

Concrete deck

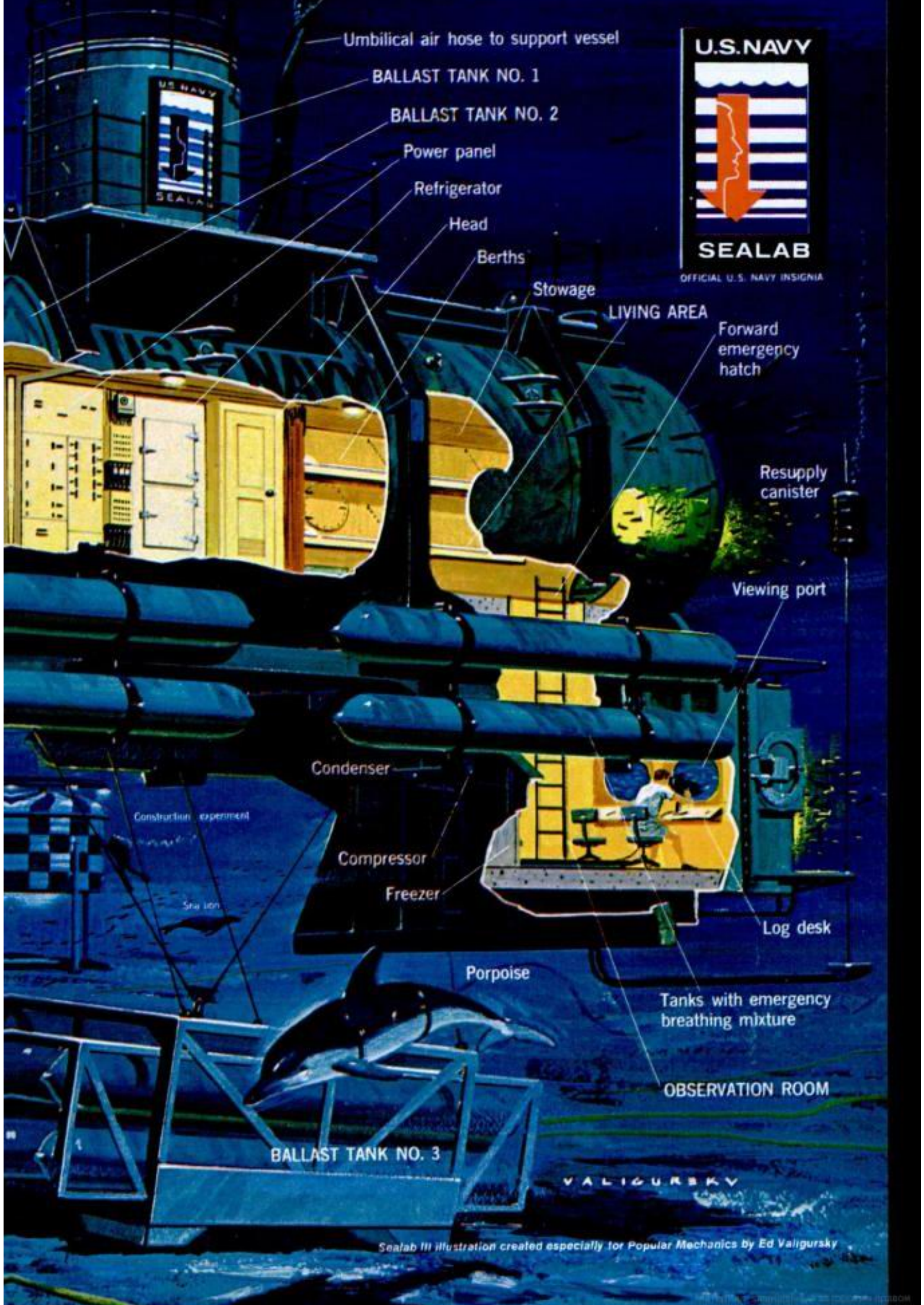
Swimming
equipment
storage

Air Hoses

Entrance
hatch

Luminous
guide lines

Divers' navigational aid



Umbilical air hose to support vessel

BALLAST TANK NO. 1

BALLAST TANK NO. 2

Power panel

Refrigerator

Head

Berths

Stowage

LIVING AREA

Forward emergency hatch

Resupply canister

Viewing port

Log desk

Condenser

Compressor

Freezer

Porpoise

Tanks with emergency breathing mixture

OBSERVATION ROOM

BALLAST TANK NO. 3

U.S. NAVY



SEALAB

OFFICIAL U. S. NAVY INSIGNIA

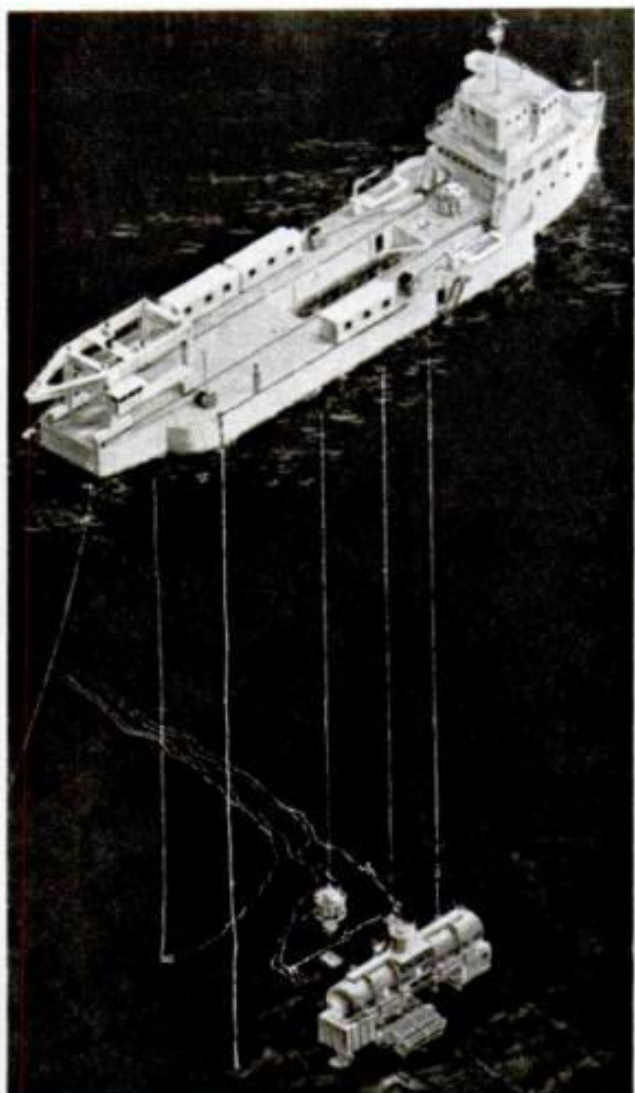
VALIGURSKY

Sealab III illustration created especially for Popular Mechanics by Ed Valigursky



SEALAB AQUANAUTS AND MEDICAL OFFICERS pose after a previous successful dive. Shown from left to right are Capt. George Bond, who initiated the program in 1957, Torpedoman's Mate Billie Coffman, Cmdr. Scott Carpenter and Capt. Walter Mazzone

IN ARTIST'S CONCEPT, support ship *Elk River* feeds transfer capsule to 600-foot level of Sealab III



fresh-water showers, desks, chairs, books, hi-fi and nearly all the comforts of home, along with a mind-boggling array of special instruments. But, unlike the earlier Sealabs, this new "life capsule" will rest at a depth of 600 feet—three times deeper than its daring predecessors. "The longest 600 feet in the world," one crew member said.

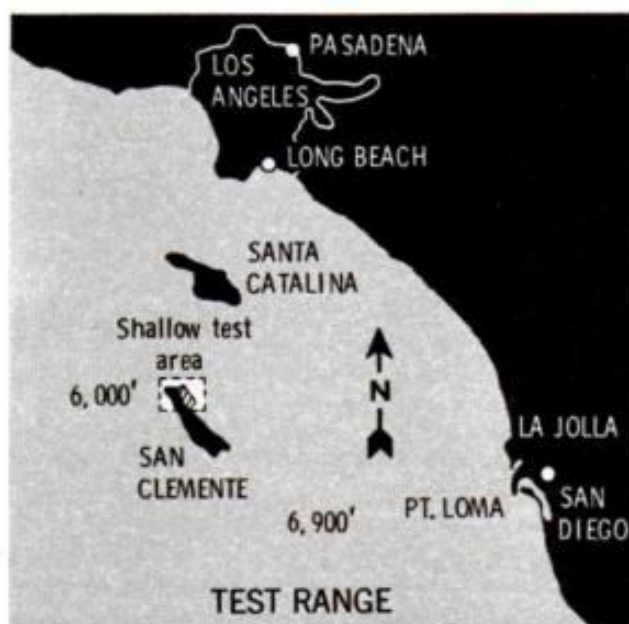
"Diving craft go deeper," a heavily gold-braided officer explained, "but in a diving craft—as in submarines—men live at normal surface pressure. They can't go outside. Our aim, by contrast, is not just traveling in the sea. It's *living* in the sea, going in and out at will like you do at your own home, working outside, and staying down long enough to accomplish major projects."

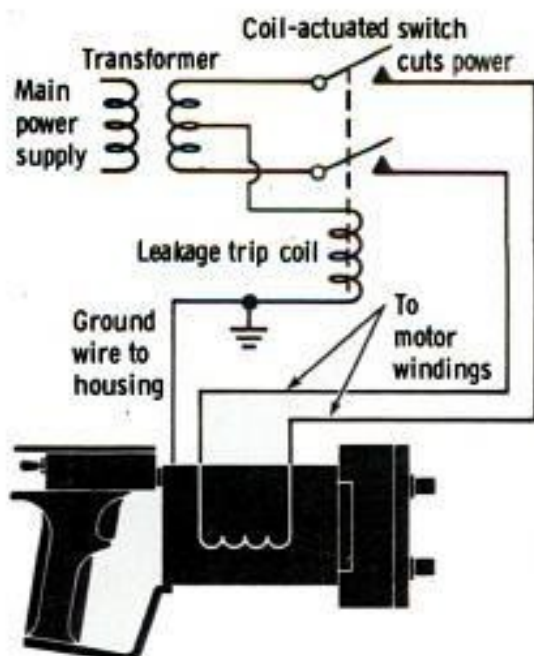
At this moment, all equipment is ready:

- The Sealab habitat—a huge steel cylinder resembling an outsize tank car, studded with portholes, floodlights, hatches, pipes, valves, ballast and auxiliary breathing tanks, painted bright yellow for underwater visibility. Moored to the ocean floor, the habitat is the basic undersea abode. From here divers swim out on work missions, dangling on 600-ft. umbilicals, going down on the sloping sea floor to depths of 750 feet.

- Two PTCs (personnel transfer capsules)—free-hanging, pressurized ele-

SEALAB SITE is just off coast of Southern California





SHOCKPROOF POWER TOOL for underwater use has ingenious safety shutoff. Any short circuit immediately trips a relay (see diagram), cutting power within 30 milliseconds—long before diver can feel a tingle

vators to lower aquanauts to the habitat and to bring them back up. Each holds four men and is hoisted up and down by a crane on the surface support ship.

- Two DDCs (deck decompression chambers)—pressurized living quarters about the size of a VW bus, located on the surface ship. On arrival from below, the PTC “mates” with the decompression chamber so that the aquanauts can transfer into the DDC under pressure. Then they are gradually decompressed over a period of 150 hours. Faster decompression would make the nitrogen in their blood bubble at body

temperature, causing the often-fatal “bends.”

- A “dry pot”—a sealed transfer chamber to deliver food, mail, newspapers and supplies to the habitat.

- A surface support ship, the *Elk River*, carrying out command and monitor functions, serving as communications center and supply store for the entire undersea operation.

The enemy to be vanquished in this Navy mission is the sea itself. It is powerful and unforgiving. The first mistake is likely to be the last. “We can’t forget this for a moment during the whole 60-day project,” says Lt. Cmdr. C. W. Larson, a Sealab briefing officer.

At 600 feet down, the sea presses in on the human invaders at a shattering 275 p.s.i. Just staying alive is a chore in this environment. Every breath becomes a scientific challenge, for at such pressure, the body reacts very differently than at the surface.

Pure air becomes pure poison. Its nitrogen, pressed into the blood by the extra pressure, knocks a man’s mind off its moorings, rendering him a helpless victim of the “rapture of the deep.” That’s why most nitrogen is removed from the aquanauts’ breathing mixture and replaced by helium—a physiologically harmless gas. Oxygen, too, must

(Please turn to page 180)



AMERICANS ARE NOT ALONE IN THE DEEP! Russia’s Sadko-2 (above) spent 10 days at a depth of about 82 feet with two men in it, and the Soviets have reported preparing Sadko-3 for further experiments, as well as Bentos-300, a transportable vehicle capable of depths close to 1000 feet, housing 10 aquanauts for two weeks

NO. 2-BY-2 STREET

Chicago's tapered
John Hancock Center will
be second only to the
Empire State

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mechanical
equipment

Television antennas

Floors 95-96:
Gourmet restaurant
with view of
four states

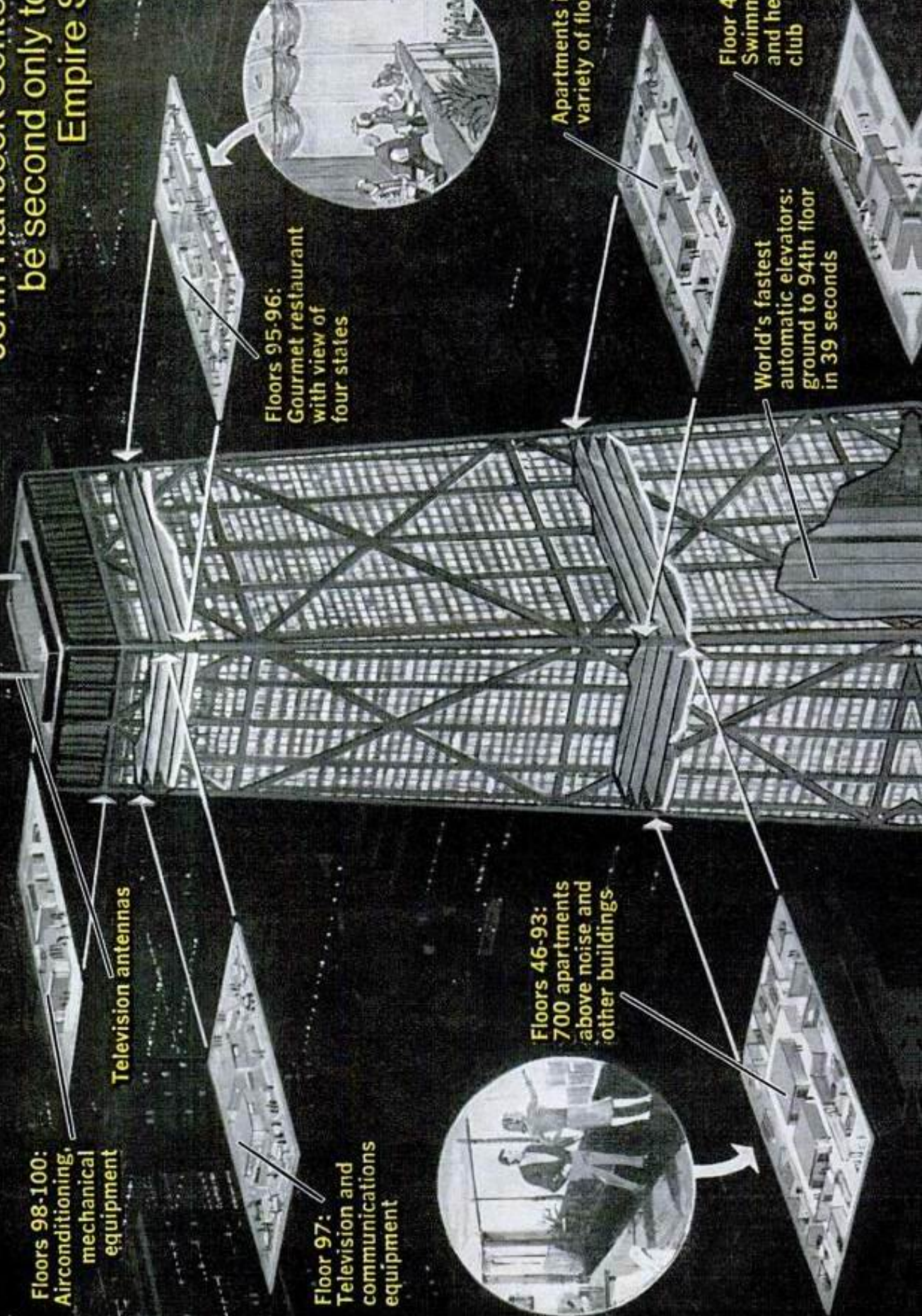
Floor 97:
Television and
communications
equipment

Floors 46-93:
700 apartments
above noise and
other buildings

Apartments in a wide
variety of floor plans

Floor 44:
Swimming pool
and health
club

World's fastest
automatic elevators:
ground to 94th floor
in 39 seconds



Floors 44-45:
Stores, restaurant
and commissary for
residents

Recessed court with
combination ice-skating
rink and reflecting pool

Floors 6-12:
Parking for 1200 cars

Below-ground
dock for trucks

Floors 13-41:
One million square
feet of office space

Empire State,
world's tallest:
1472 feet
(with antennas)
102 floors

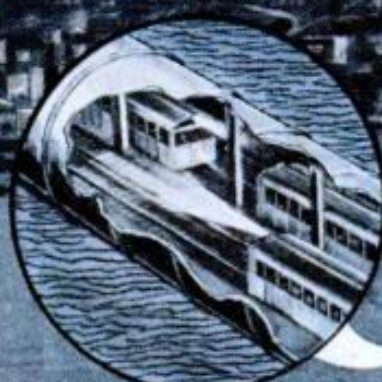
John Hancock:
1451 feet
(with antennas)
100 floors

Spiral ramp
connects ground
level and
parking area

HERB
WYATT

Future Airports: How are we

Rapid-transit subway



Hydrofoil shuttle buses

Connecting causeway

Jumbo jet transport

Rapid turnoff taxiways

Maintenance area

Marinas

Dam

Approach lighting system

Landing runway

Supersonic transport

Illustration by Monroe Eisenberg

going to get 'em out to the field?

By KEVIN V. BROWN

Handling the big new jets will be easier than handling their passengers. Here's how you may be traveling to and from the terminals

Underpass

Helicopter
landing
port

STOL
landing
port

Marina

Central
terminals

Underground
shuttle

Control
tower

Satellite
terminals

Underground
parking

Cargo
port

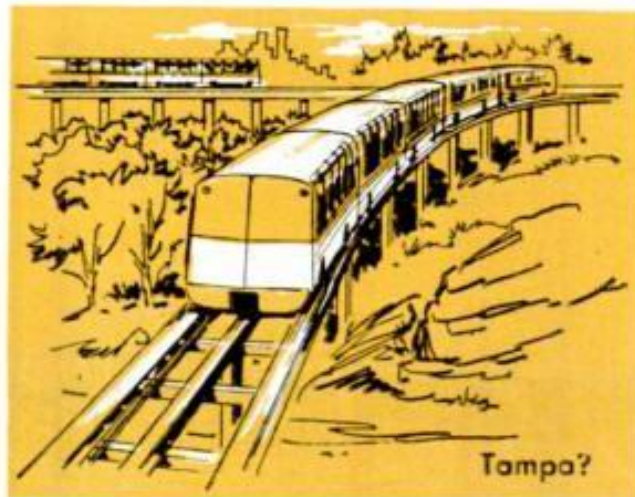
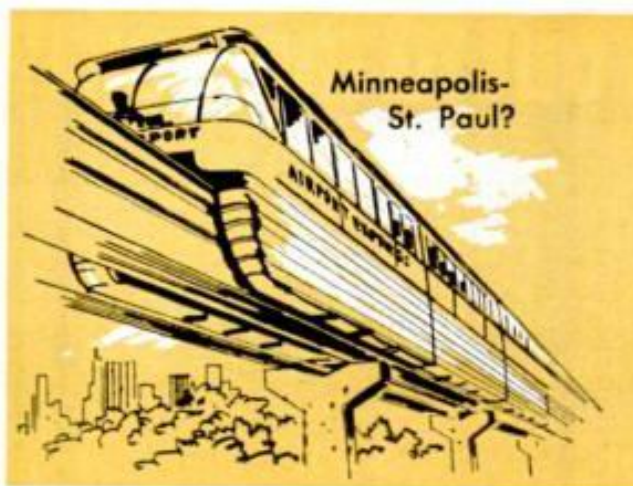
Fuel
port

Fuel
storage
tanks

Takeoff
runway

YOU CAN'T LAND at this airport just yet, and it's possible you never will. But Chicago is thinking seriously—and spending money to support that thinking—of building a new jet airport offshore on the bottom of Lake Michigan.

It's probably the most far-out solution to a problem that is vexing city planners throughout the world. With more and more people flying, and bigger and faster airplanes being built to carry them, shuttling these crowds between the cities and the loading gates has become a major bottleneck. Chicago's plan is to break the



bottleneck by bringing the airport downtown, but other communities are studying new and novel ways to carry the passengers out to the airport.

Dallas and Fort Worth will share the new Dallas-Fort Worth Regional Airport and may build a special spur from the expressway that joins them.

Tokyo already has a monorail to the airport, and other cities are considering such a system.

Tampa, Fla., is seriously thinking about a rubber-tired, completely automatic, overhead train.

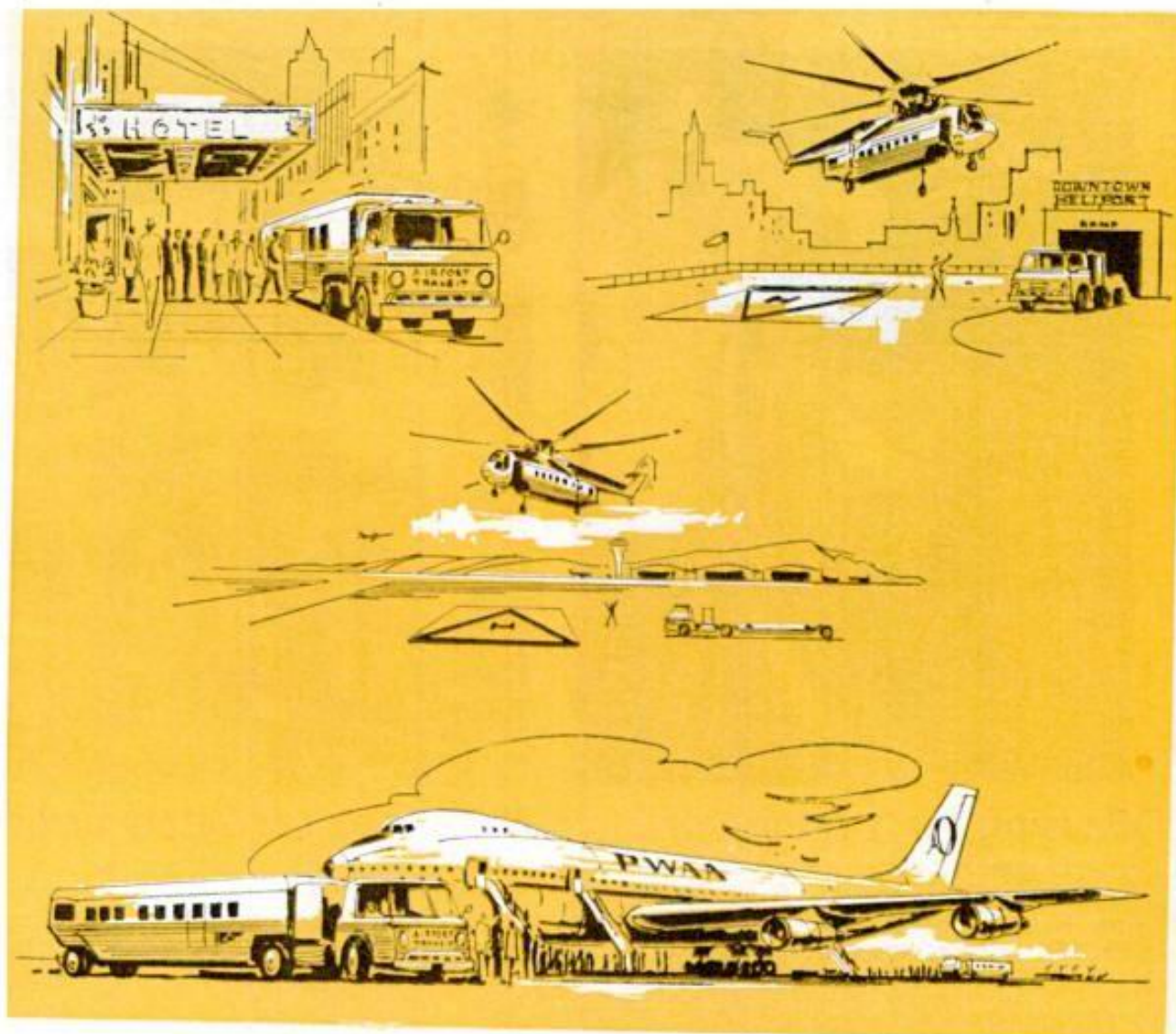
New York City, where air passengers have nearly doubled in five years, has tested a bus that also rides on rails, picking up passengers on city streets, then lowering its metal wheels and making most of the trip on rails.

Still others, notably Los Angeles, are well down the road—or up in the air—on new vertical-rising aircraft that can take off from downtown locations, rise straight up, then scoot above traffic to the airport.

The Chicago plan, however, is by far the “farthest-out.” A lake-bottom airport would be built a few miles offshore, where the water depth is about 30 feet. The water would be dammed off and the entire complex would rise from the lake bottom. An underground rapid-transit system or an overwater causeway would connect the airport to the downtown area, a distance of just a few miles. Special features of a lake airport would be docking facilities for oil tankers or other cargo vessels, a marina for local sailors, even a beach. With the runways running north-south, planes would avoid flying over congested areas, and, if necessary later, the runways could be extended indefinitely.

Other areas have been thinking similar thoughts. Los Angeles has studied a plan to build an offshore “sea-drome”

NEW SYSTEMS for getting to and from outlying airports, and avoiding bottlenecked street traffic, include (from top) monorail trains, which would carry large numbers on direct trips; STOL and VTOL aircraft, which fly above traffic; rubber-tired trains that operate automatically without motormen, and combination bus-trains that ride either on tires or rails



SOPHISTICATED LOS ANGELES system would use bus "pod" to pick up passengers at hotels, then drive to heliport, where flying crane would pick it up then fly it to airport, where bus would drive out to plane

which would float on *top* of the water, and England has studied another one which would include an intercontinental airport on one of the sandbanks in the English Channel.

Such solutions, however, are available only to those areas that have open water nearby and can bring the airport closer to the passengers. Others have to fall back on new ways to shuttle passengers to the airport.

Expressways, in spite of exotic new rapid-transit systems, will predominate. Aviation experts point out that most people prefer to drive on at least one end of a flight, because of the convenience of getting to or from their homes, and many then rent cars at the other end of the trip.

Multiple-deck expressways may evolve. Some terminals already have

two levels, one for departing passengers and the other for arriving passengers, but at least one expert is urging "vertical terminals" of six or more levels, either above or below ground. Four levels would be used for parking, ending the added delay of getting into or out of an open-air lot. Expressways, starting far from the field, would then become multilevel to match terminal levels, again speeding traffic and eliminating bumper-to-bumper approaches.

Even so, some airports hope to reduce, if not eliminate, auto traffic by building more attractive rapid-transit systems. Mass transport of hundreds of passengers in just one vehicle, instead of in scores of automobiles or taxis, is an appealing proposition.

Paris, which is now building its new
(Please turn to page 178)

The Big Rise of The Little Sinkers

A population explosion has occurred among research submarines. These small underwater craft are now preparing to invade man's last frontier—the ocean floor.

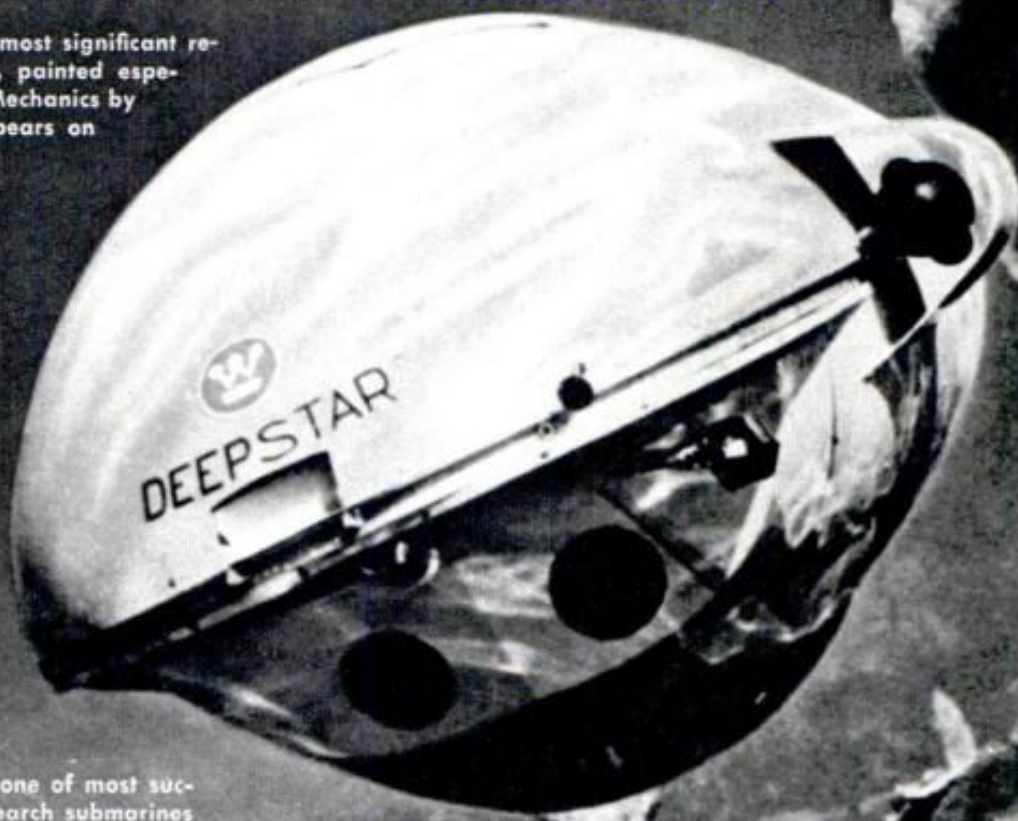
By WALLACE CLOUD

ALEXANDER THE GREAT went down into the sea in a "glass barrel" in 323 B.C. and reported he saw a fish so big it took three days to swim past. That story nearly finished off oceanography. Sensible men knew their observations below the surface wouldn't be believed, so they refrained from eyeballing the undersea environment for a good long while.

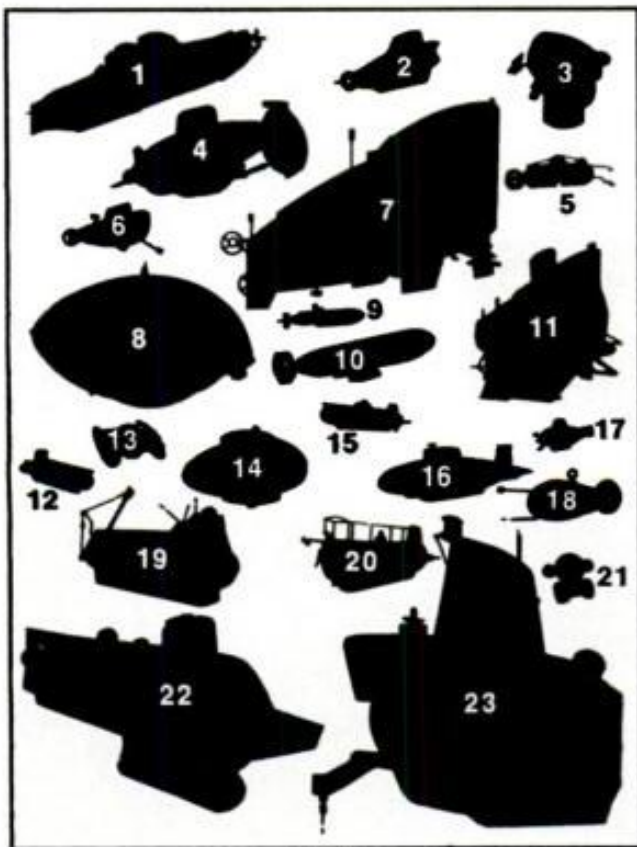
Courage has revived, however, and now it's the fish who can hardly believe their eyes. A population explosion among scientific submersibles has mushroomed in the last

(Text continues on page 114)

Artist's concept of most significant research submarines, painted especially for Popular Mechanics by Ed Valigursky, appears on next two pages.



DEEPSTAR 4000 is one of most successful of new research submarines



KEY

1. CUBMARINE PC3B 2. JES (Japanese Experimental Submarine) 3. DEEP JEEP 4. STAR III 5. YOMIURI 6. AUTEC I 7. TRIESTE II 8. DEEPSTAR 4000 9. DOLPHIN 10. DSRV (Deep Submergence Rescue Vehicle) 11. ARCHIMEDE 12. AUGUSTE PICCARD 13. HIKINO 14. DOWB (Deep Ocean Work Boat) 15. NR-1 16. DEEP QUEST 17. ASHERAH 18. BEAVER MARK IV 19. PX-15 20. ALUMINAUT 21. SPUVA (Self-Propelled Underwater Viewing Apparatus) 22. DEEP DIVER 23. ALVIN

MOST FAMOUS small submersible is probably Alvin which found missing H-bomb off coast of Spain

few years. Since Prof. Auguste Piccard took the first dive with *Trieste* in 1953, nearly 40 of the little sinkers have been built, and more are under way.

They *do* look odd. A typical research sub generally has a maze of scientific hardware dangling from it, including instruments, cameras, lights, sonar gear, manipulating arms, bottom-sampling devices and corers. Fish never saw anything like that!

Aluminaut, built by General Dynamics for Reynolds Metals, discovered a "smooth, black pavement" consisting mainly of manganese oxide at a depth of 3000 feet on the Blake Plateau off Florida, and explored it by trundling along on *wheels*.

Deepstar 4000, a follow-on to Jacques Costeau's original diving saucer, sneaks up on unsuspecting marine life and, with a device bearing the scientific nomenclature, "the slurper," slurps up animals for study on the surface. *Deepstar* is one of a family of small submersibles built by Westinghouse Electric Corp.

Between dives to inspect earthquake cracks on the sea floor, *Yomiuri*, a Japanese sub named after and owned by a Tokyo newspaper, brings back live





Science 'Cities' Under the Sea

Here's how man may occupy the Mid-Atlantic Ridge for science, exploration and military use—all within the next ten years

By WALLACE CLOUD

Color Illustration by Ed Valigursky

WE KNOW MORE about the back side of the moon than about the ocean's bottom," quips a Navy scientist, and you know he's talking about the relative lack of federal money for oceanography, compared to the space effort. In undersea circles, some gripe that there's more to be gained through conquest of the deep frontier here on earth. There's even a move for creation of a new U.S. science agency—a "wet NASA"—to focus public attention, funds and research on the depths.

Best-informed sources consider it unlikely that a wet NASA will be set up, or that ocean science will grow at the expense of space. Both are important. But there's no doubt that deep-sea projects will be increasingly supported and will generate excitement of their own. Within 10 years, for example, it should be possible to assemble a scientific colony thousands of feet below the surface atop the seamounts of the Mid-Atlantic Ridge. A laboratory "city," populated by some hundreds of scientists, would concentrate intensive research on one area of the ocean bottom, in much the same spirit as the coordinated exploration of the Antarctic.

Providing a variety of depths down to about 15,000 feet, the seamounts could be used as platforms for several kinds of undersea bases. Perhaps an area near the Azores would be selected. These islands, poking up from the ridge, would be useful as a staging area convenient to America and Europe.

Oceanographers have been studying

the worldwide mid-ocean ridge system avidly since its discovery in the late 1950s. A major feature of our planet's geography on which man has never set foot, the system forms an immense mountain range (largest on earth) made of rock pushed up from a "crack in the world" along which earthquakes occur continually. Undersea volcanoes, never observed by man, erupt there.

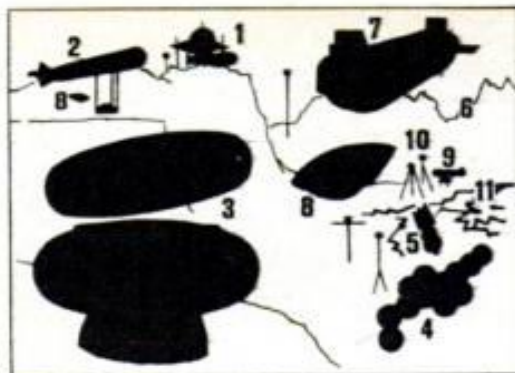
Big companies are already devoting a sizable research effort to development and testing of concepts for ocean-bottom habitats. Much of the material for the accompanying illustrations came from discussions with scientists at General Electric and Westinghouse, two companies with some of the most interesting ideas for undersea stations.

The U.S. Navy would play a major role in setting up such a research base. In an age when nuclear subs cruise submerged for months, undersea warfare experts have many ideas on military use of the sea floor. They're not talking about details, but it's apparent that "taking the high ground" will become crucial, as it is in land warfare. "If we can control the ridges, we can control the oceans," one weapons-oriented scientist told me.

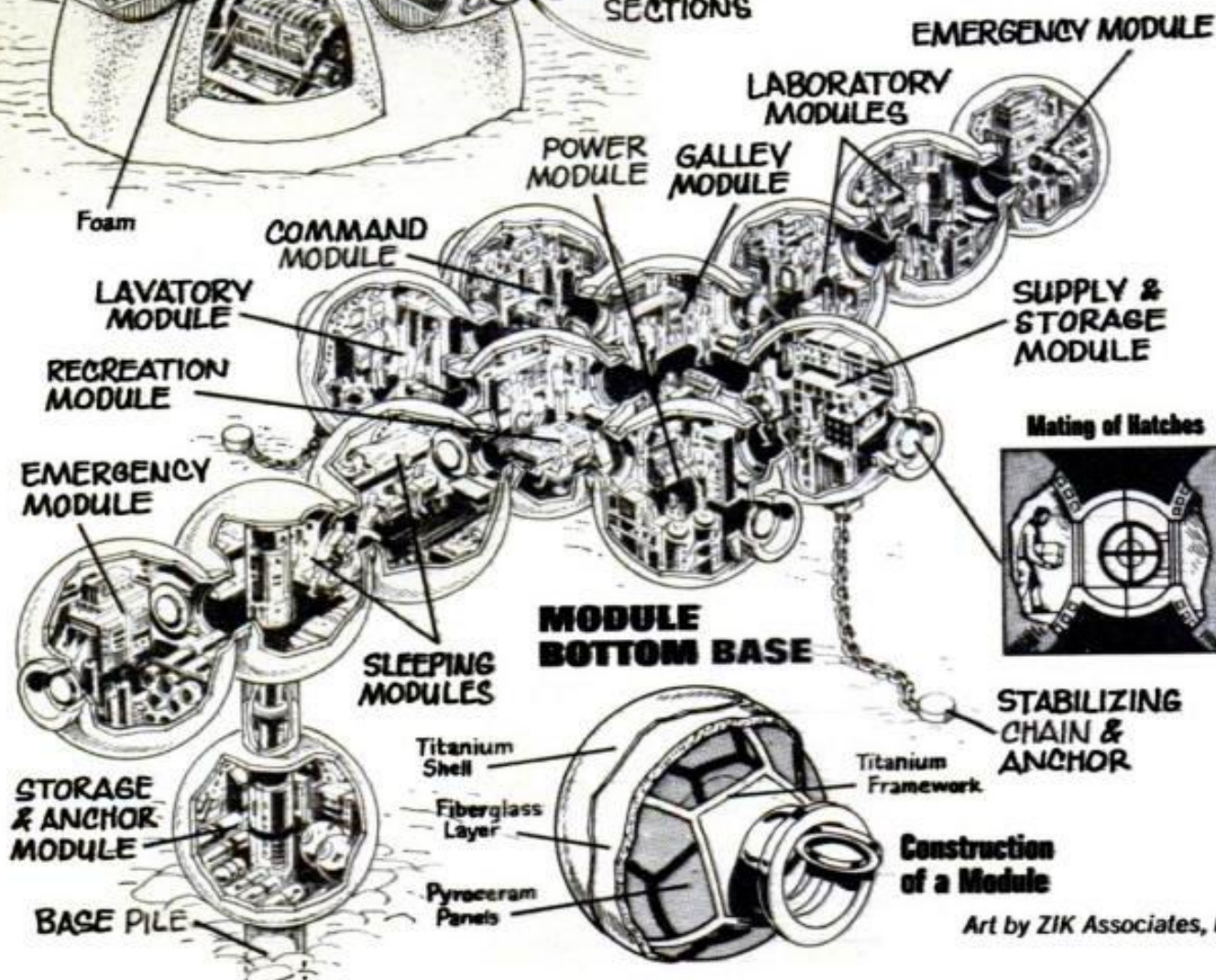
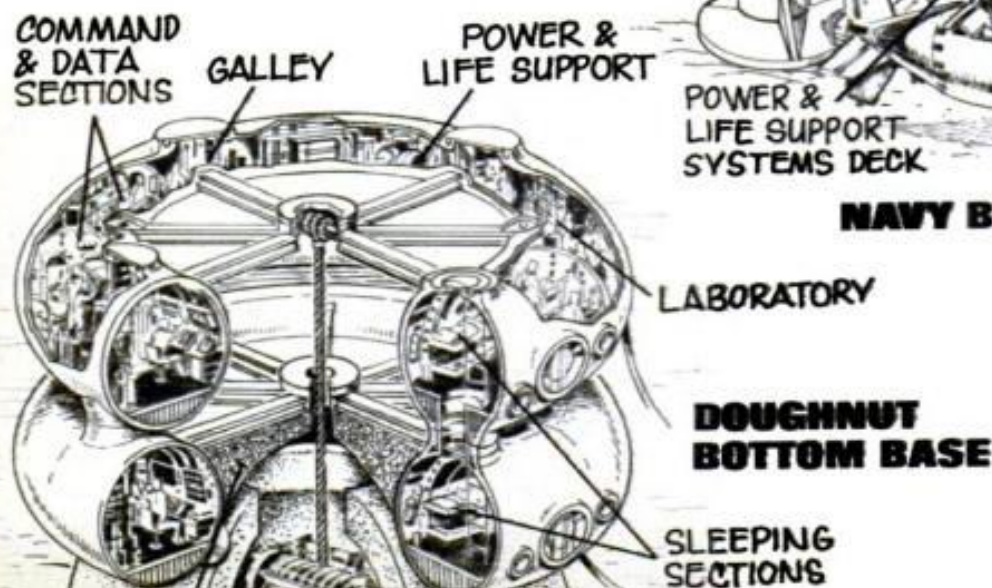
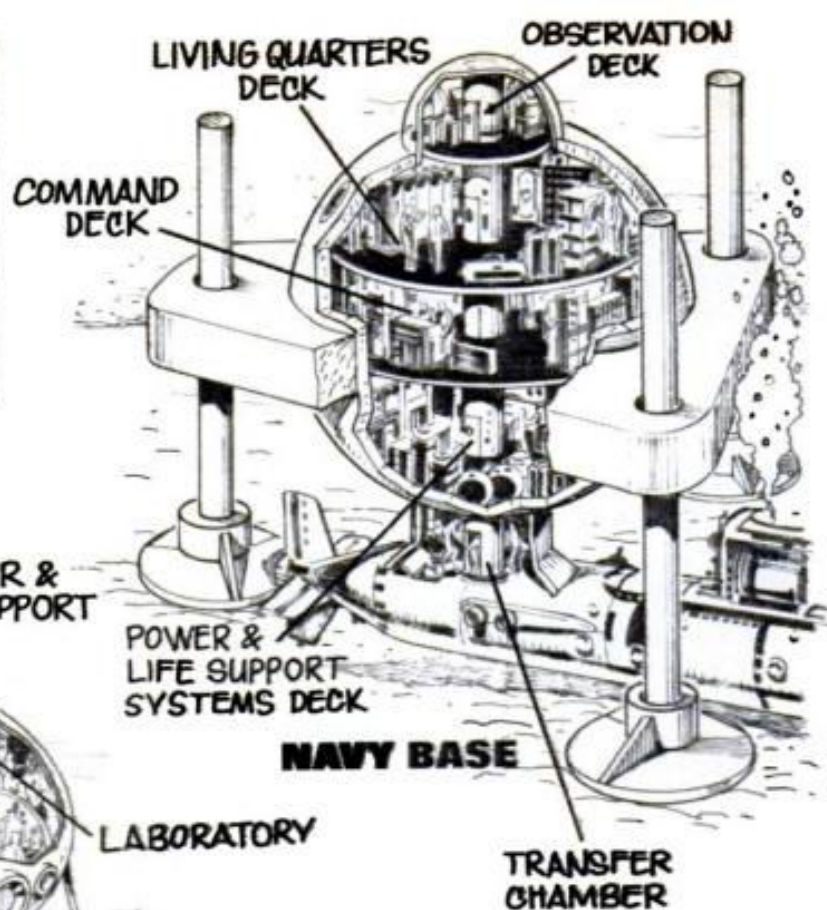
The Navy has awarded several contracts to study designs for undersea

(Text continues on page 127)

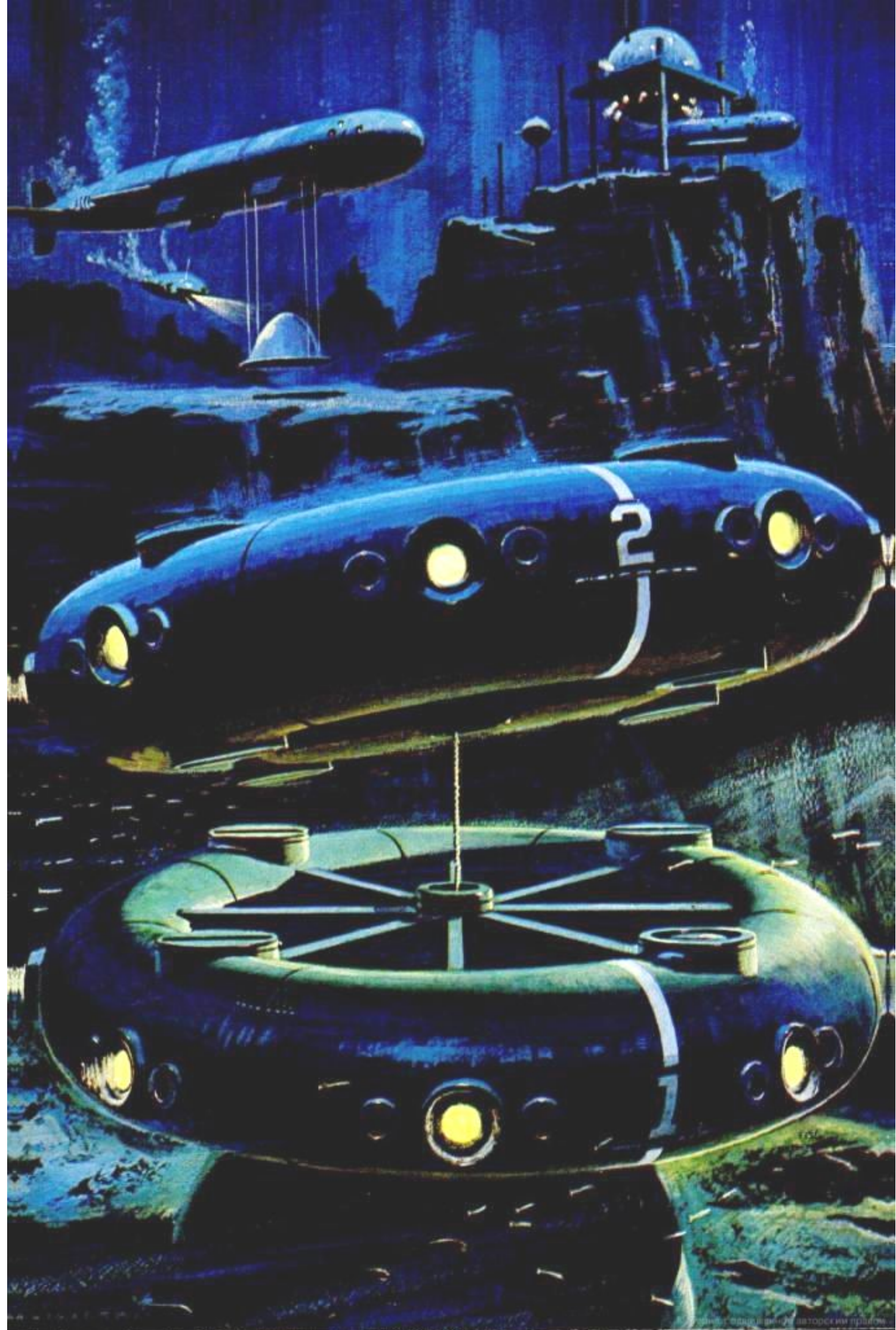
WHAT WILL AN UNDERSEA SCIENCE CENTER LOOK LIKE? Turn the page for a view, in color, of man-made labs on the Mid-Atlantic Ridge, painted as if our eyes could pierce the gloom of the deep ocean.

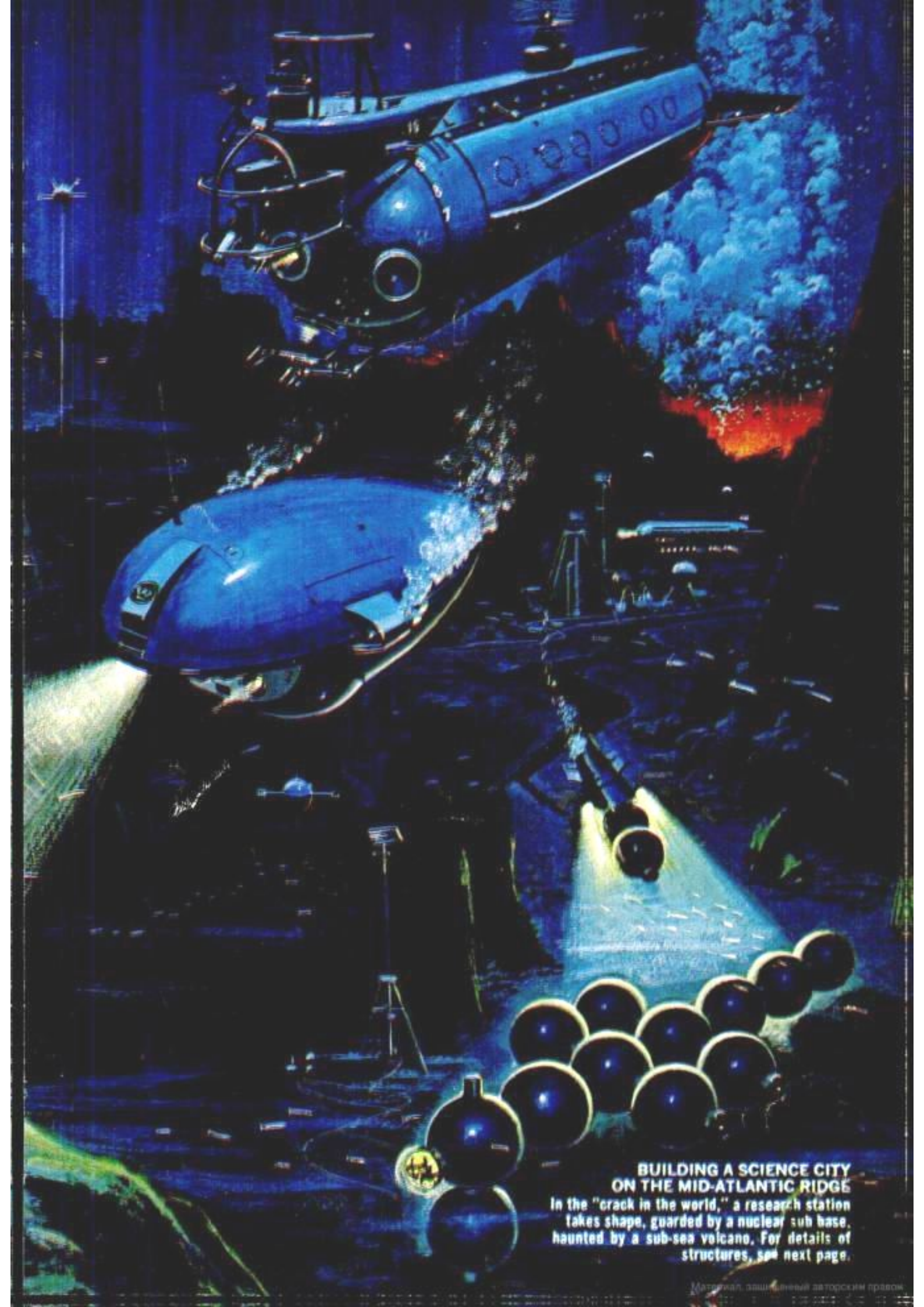


KEY to painting on pages 124-125: 1. Navy base
2. Cargo sub 3. Doughnut bottom station 4. Module
bottom station 5. Ferry sub 6. Undersea volcano
7. Aluminant 8. Deepstar 9. Excursion vehicle
10. Data collecting stations 11. Volcanic fissure



Art by ZIK Associates, Ltd.





**BUILDING A SCIENCE CITY
ON THE MID-ATLANTIC RIDGE**
In the "crack in the world," a research station
takes shape, guarded by a nuclear sub base,
haunted by a sub-sea volcano. For details of
structures, see next page.

Soon we'll be able to save men from sunken submarines. Here's how tiny rescue subs now being built for the Navy will bring them back alive.

ON APRIL 10, 1963, the nuclear submarine *Thresher* sank in the Wilkenson Deep off New England. Although the Navy had saved men from submarines disabled at lesser depths, such as the *Squalus* in 1939, it was powerless even to attempt a rescue of the 129 aboard the *Thresher* which went down in 8000 feet of water. Only two vessels in the whole world were capable of descending to such a depth, and all they could hope to do was look around. One of them, the bathyscaphe *Trieste*, was brought from the West Coast. It was nearly five months before it located the main wreckage.

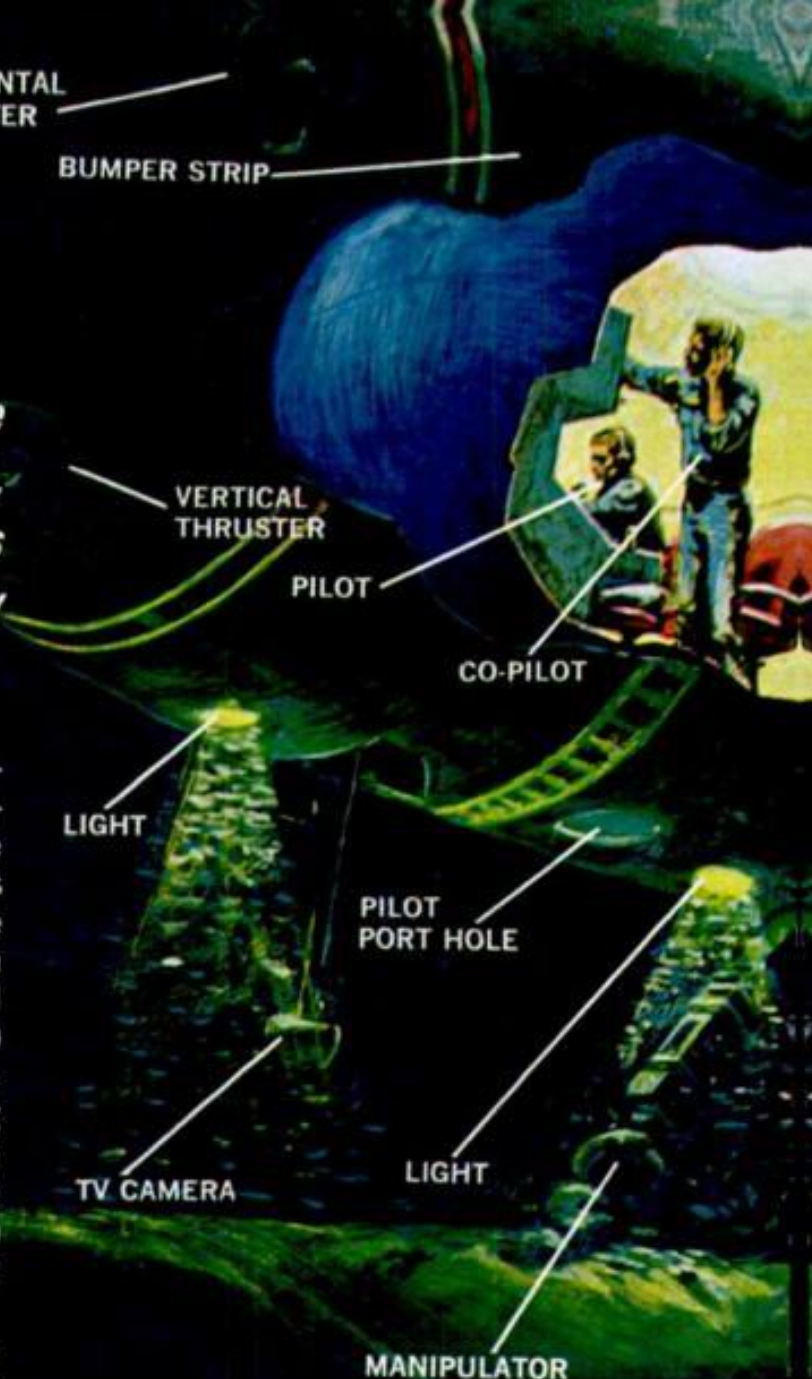
While nothing could have saved the men aboard the *Thresher*, which sank in water so deep it was crushed by the

Rescue from

weight of the sea, the Navy is determined to rescue the crew of any submarine that gets into trouble down to the "crush depth" of modern subs — a top-secret figure.

Heart of the Navy's plan is a fleet of 50-foot submarines called Deep Submergence Rescue Vehicles (DSRV). When fully operative, this system will have six such subs located in six strategic spots around the world.

A distress call from a stricken nuclear



UNDERSEA

CORPSMAN

TOPSIDE HATCH

COMPENSATING
BALLAST

TILTING PROPELLER
SHROUD

TV PERISCOPE

SHOCK
ABSORBERS

HORIZONTAL
THRUSTER

MERCURY
BALLAST TANKS

OXYGEN TANKS

LIGHT

ANCHOR AND
WINCH PORT

RESCUE SUB
MATING SKIRT

STABILIZING FIN

VERTICAL
THRUSTER

TV-CAMERA

the Deep!

ESCAPE TUBE

By Walter B. Hendrickson Jr.

Illustration by Ed Vebell



6. TAKING OFF — Jet fires up, float retracts

5. SURFACING — Float extends, air intakes open

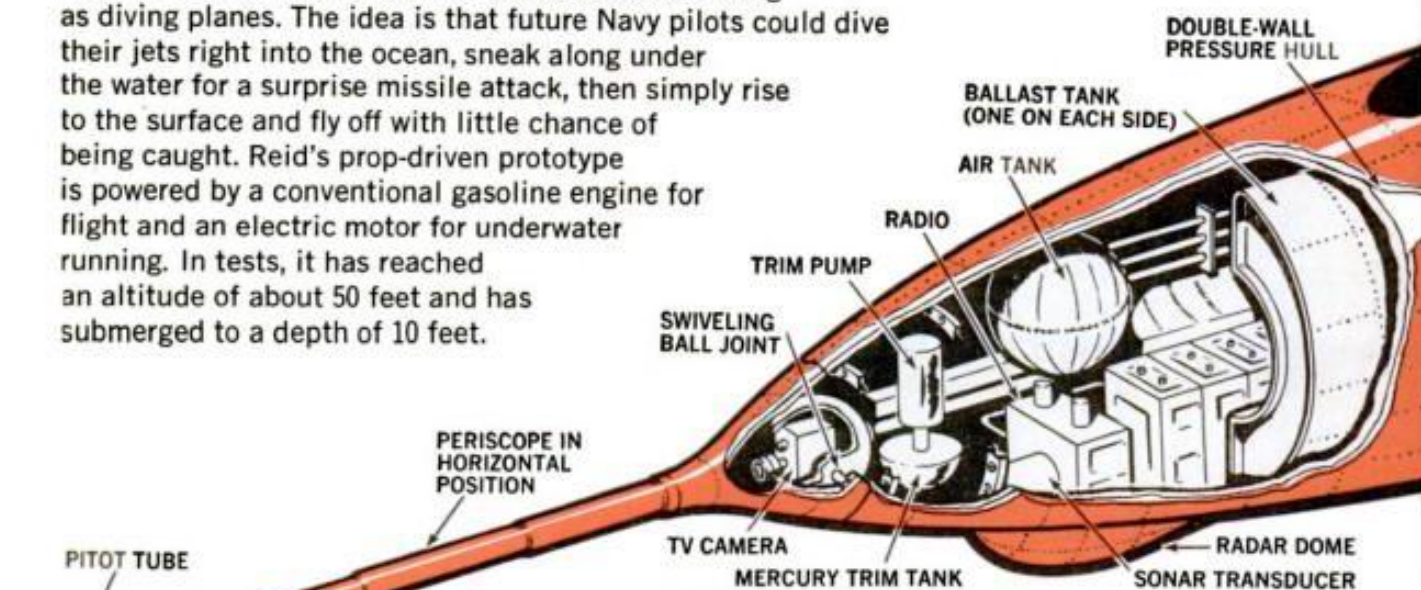
4. CRUISING — Periscope swings up, underwater engine takes over

INVENTORS SHOW FEATURE:

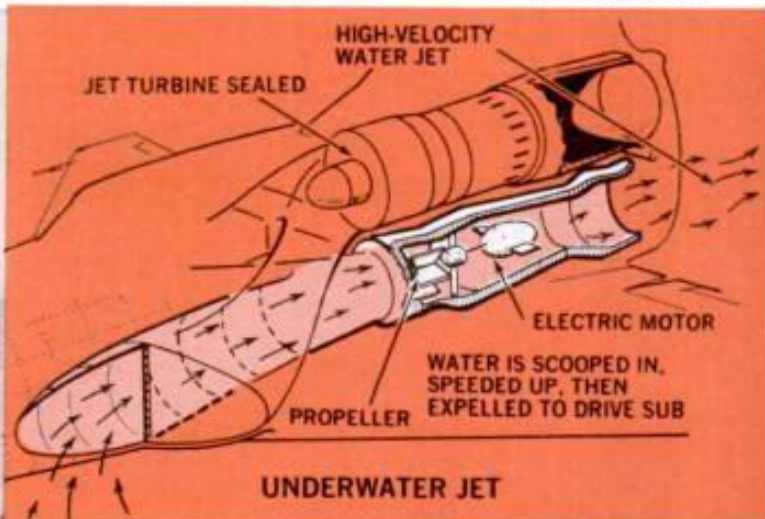
Fantastic Flying Sub

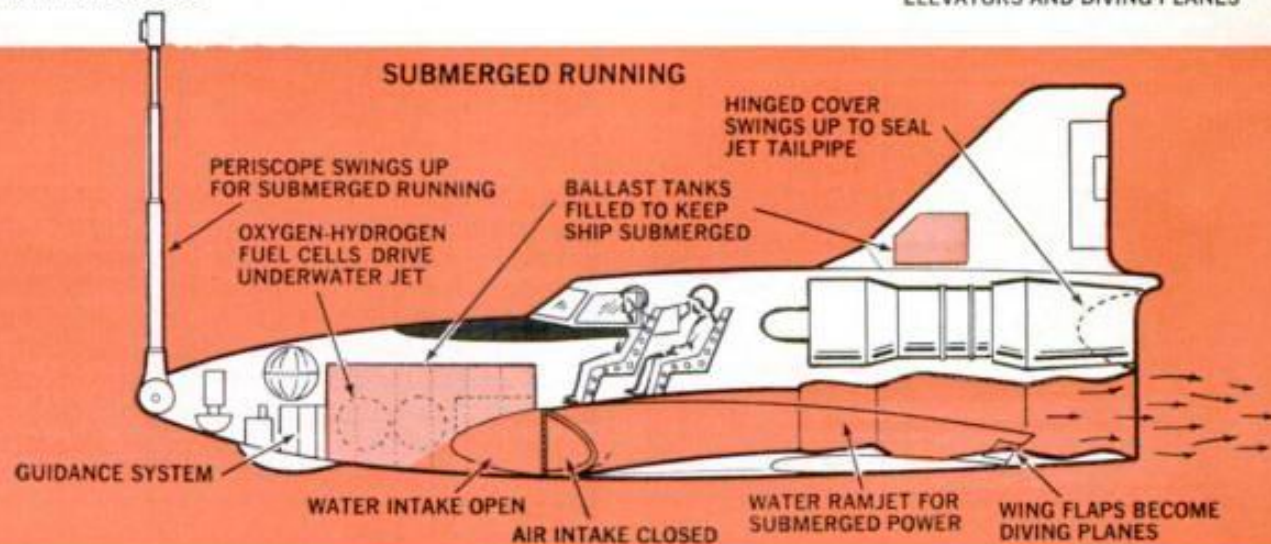
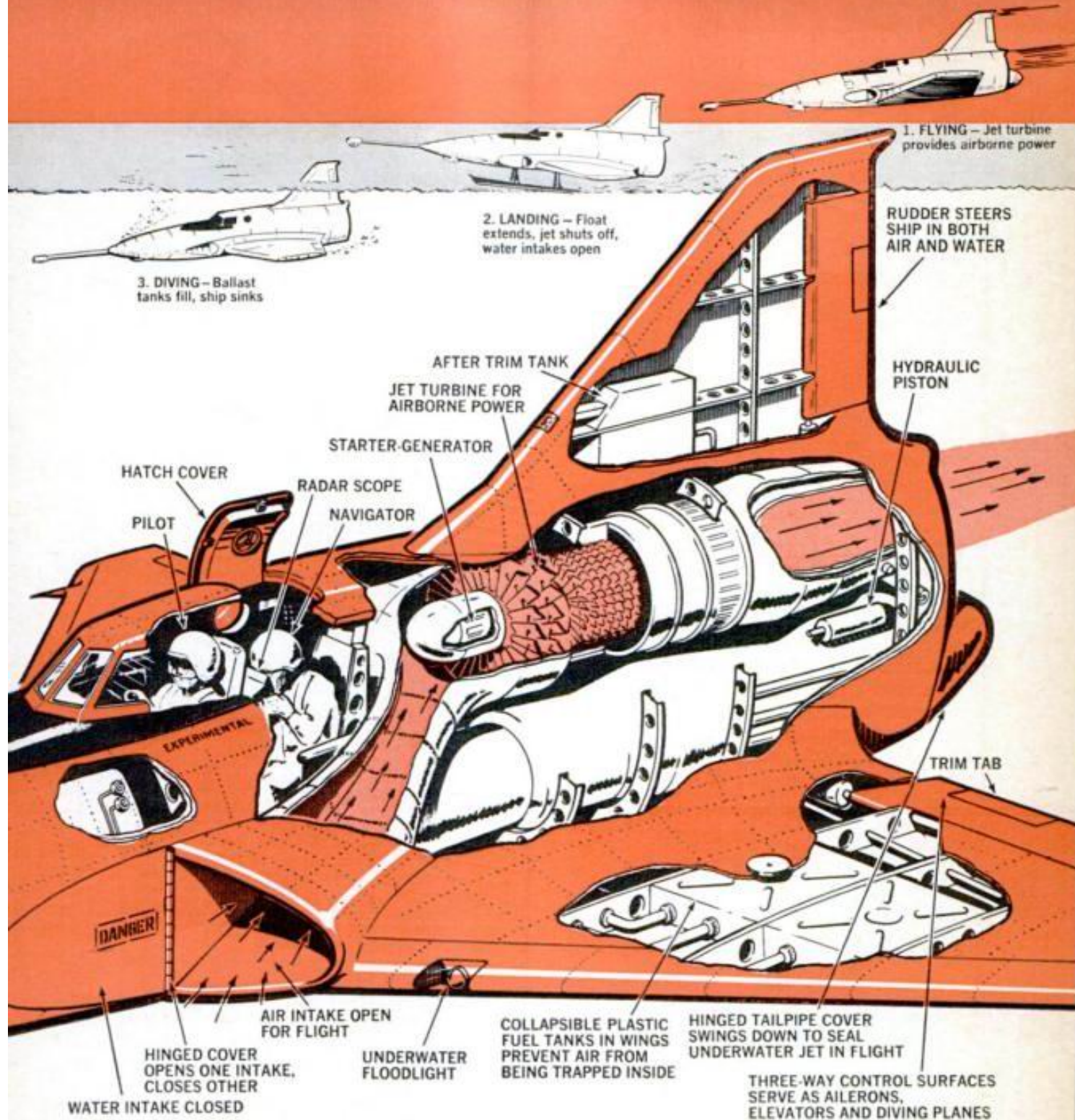
Technical Art by Donald Evans

One of the top crowd-gatherers at the Inventors Show will be a strange-looking craft designed to fly like an airplane and submerge like a submarine. Shaped like a cigar, the propeller-driven ship, shown in the photo below, is a forerunner of a more advanced jet-powered version represented in the artist's conception at right. The inventor, Donald V. Reid of Asbury Park, N.J., plans to have both the prop-driven prototype and a mock-up of a jet model on view at the show. The jet ship has a novel two-way intake system that scoops in air for flight and water for submerged cruising. A clever swivel-mounted nose boom swings up to become a periscope under water. The control surfaces work in both air and water, with the elevators doubling as diving planes. The idea is that future Navy pilots could dive their jets right into the ocean, sneak along under the water for a surprise missile attack, then simply rise to the surface and fly off with little chance of being caught. Reid's prop-driven prototype is powered by a conventional gasoline engine for flight and an electric motor for underwater running. In tests, it has reached an altitude of about 50 feet and has submerged to a depth of 10 feet.



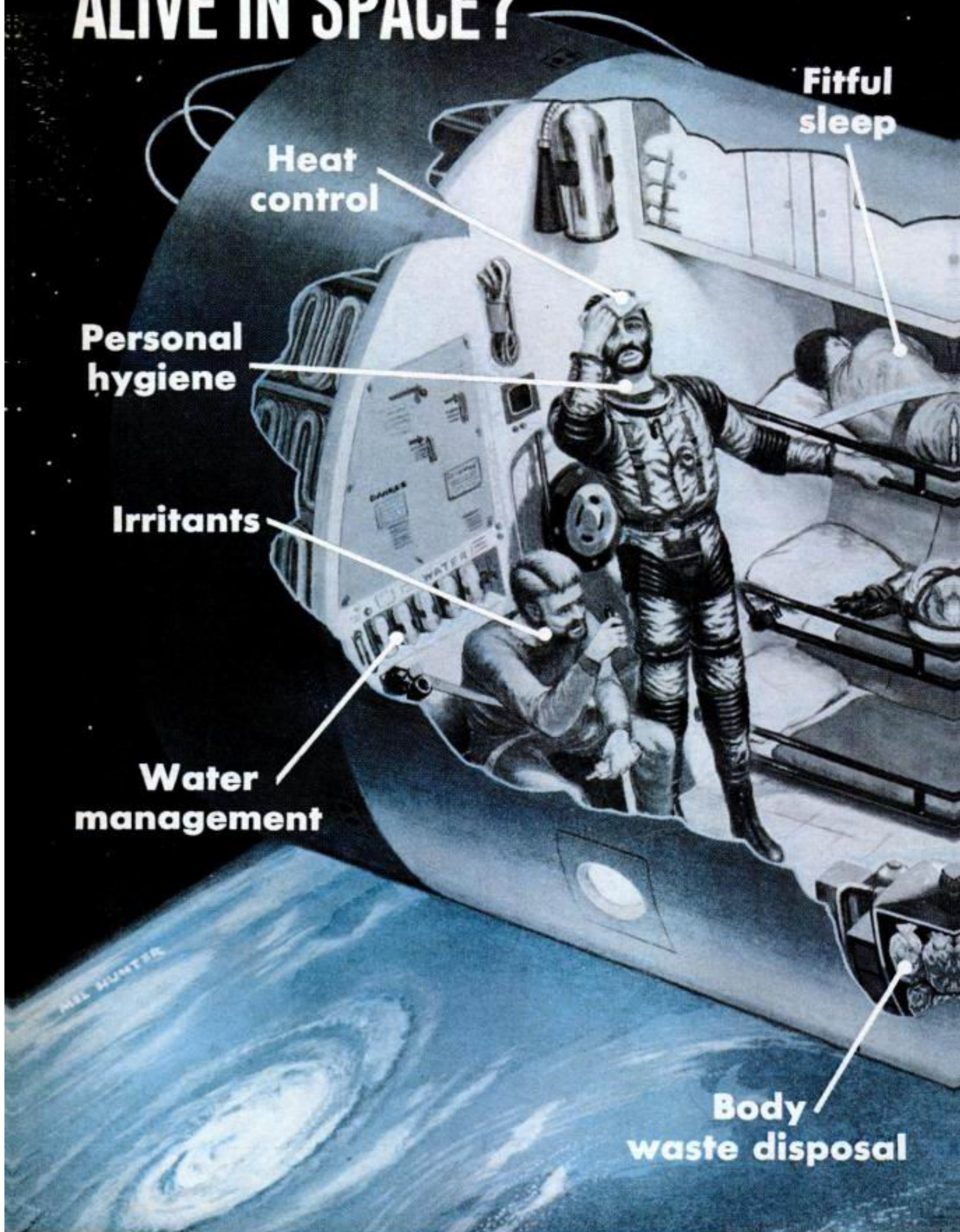
PROP-DRIVEN VERSION of the flying sub is 28 ft. long, has actually flown





CAN WE KEEP OUR ASTRONAUTS ALIVE IN SPACE?

By KEVIN V. BROWN



Here, indicated on an artist's concept of a future spaceship, are 10 unsolved problems our life-support scientists must solve

Carbon-dioxide control

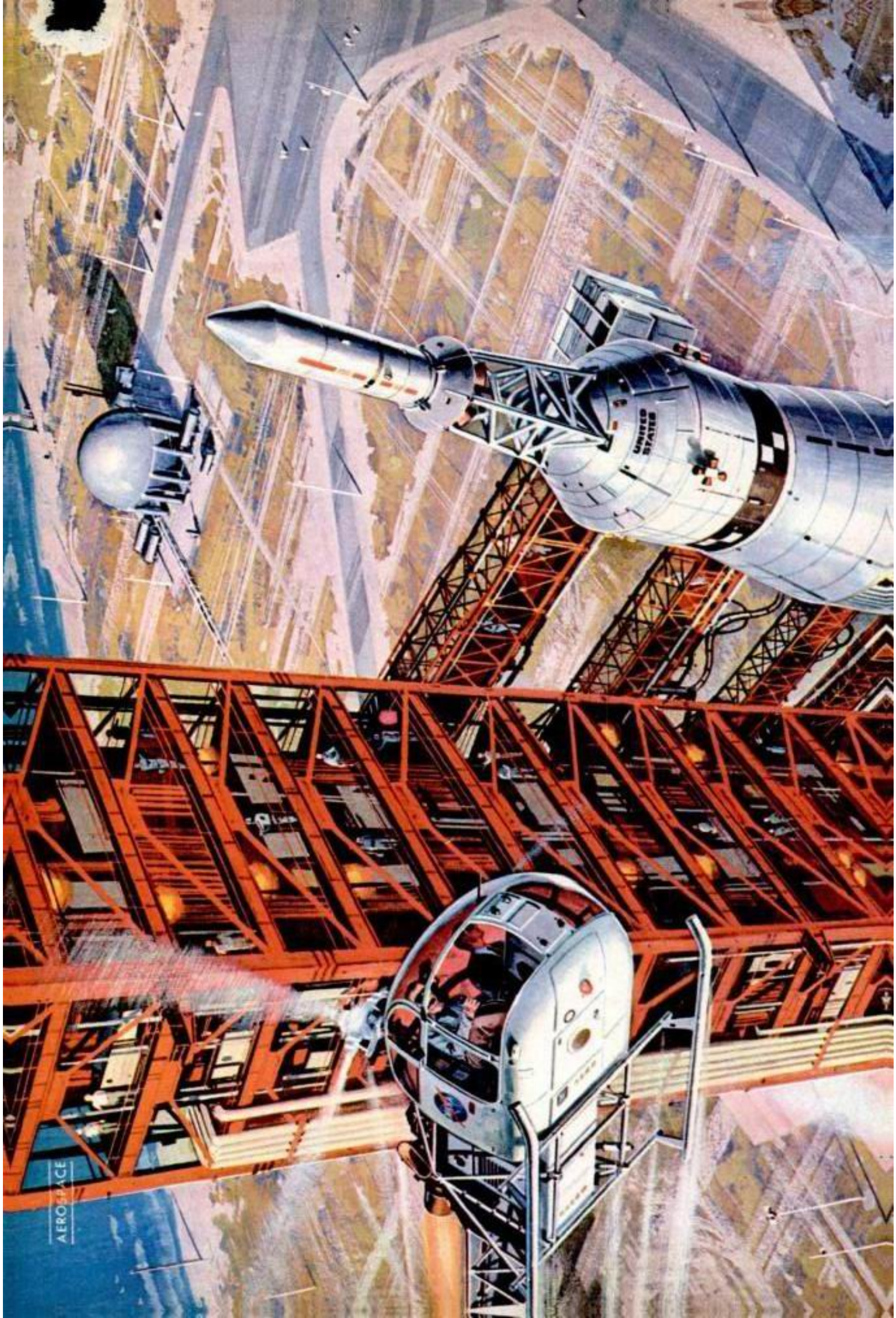
Humidity control

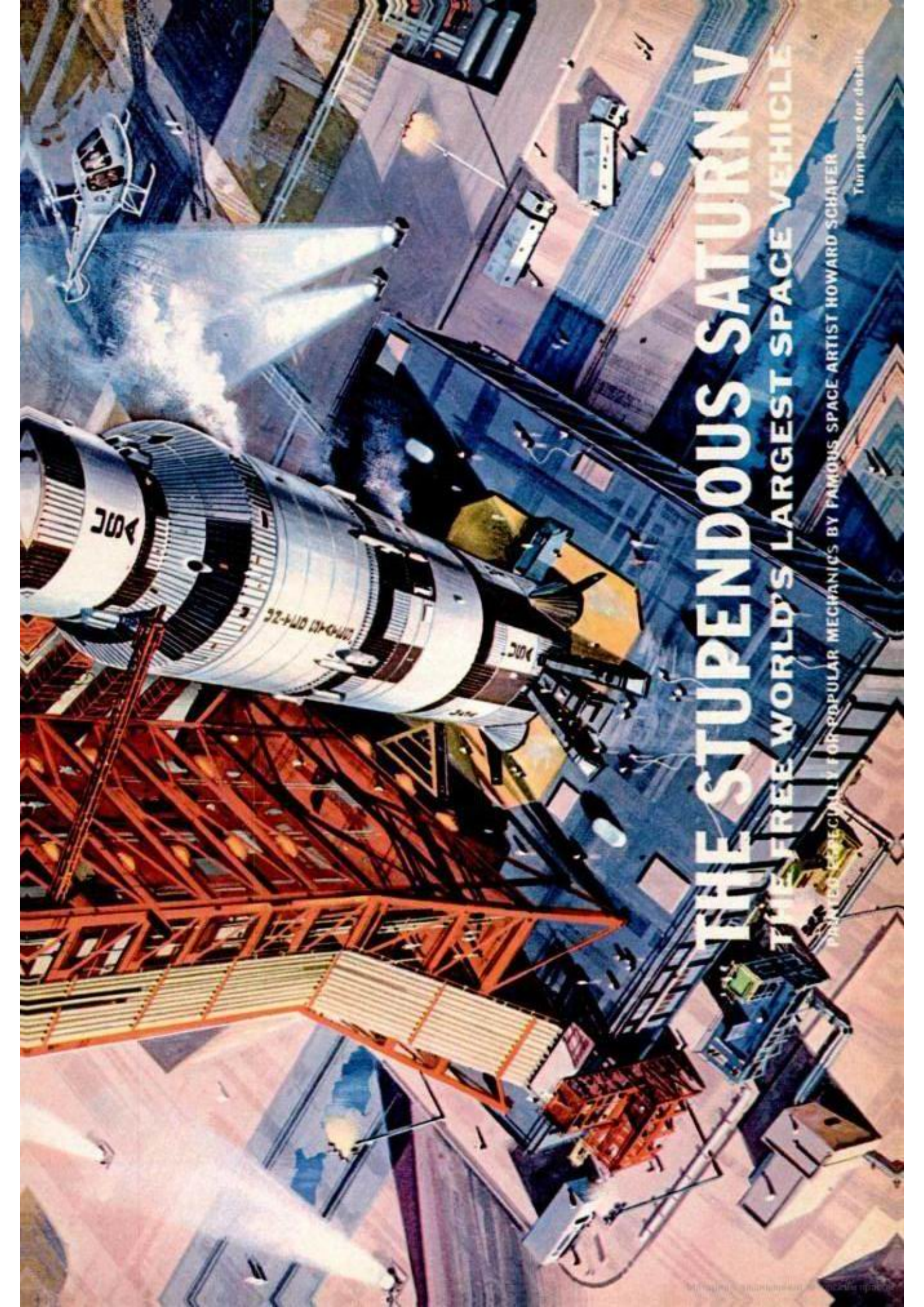
Food management

Inactivity

FOR SOLUTIONS TO SOME OF THE PROBLEMS TURN PAGE





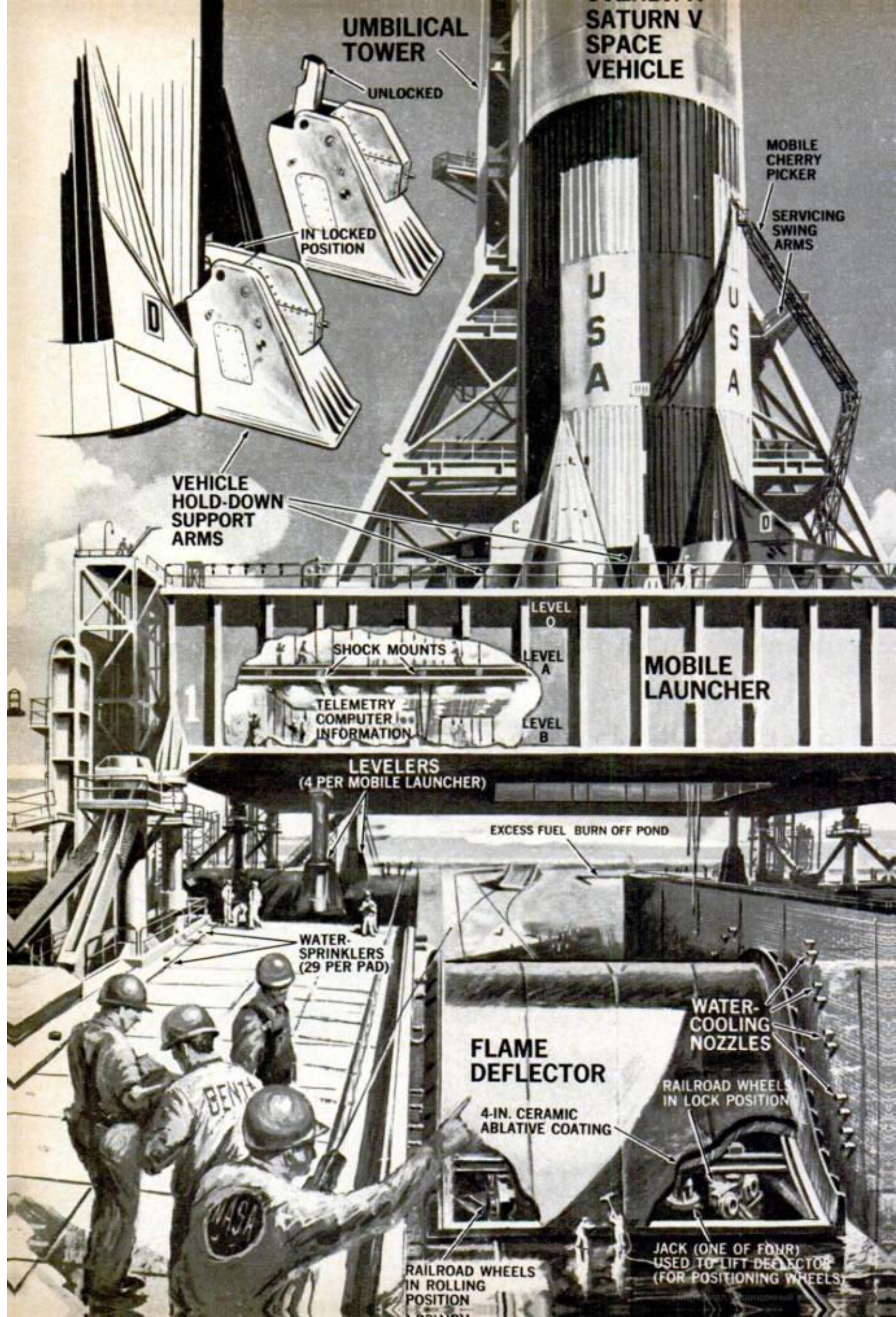


THE STUPENDOUS SATURN V

THE FREE WORLD'S LARGEST SPACE VEHICLE

PAINTED SPECIALLY FOR POPULAR MECHANICS BY FAMOUS SPACE ARTIST HOWARD SCHAEFER

Turn page for details



MOBILE
LAUNCHER

1
SIDE 1

Inside the World's Biggest and Hottest Pad

JUST GETTING IT to the pad is a problem. Saturn V, our monstrous moon rocket — due to be test-launched soon — is so big and its blast so powerful that they had to create an entirely new complex for it and a whole new set of rules.

Complex 39 is set apart and different from any of the other launch complexes at Cape Kennedy. First of all, the Saturn V isn't assembled on the launch pad, but in a gargantuan vehicle assembly building (VAB) three miles away. That's to insure that, among other things, when the vehicle is moved to the pad, the launch crew back in the control center at the VAB will be safe from the blast.

To make this move, entirely new machinery and new techniques had to be created. The three stages of Saturn V, plus the Apollo spacecraft, are mated in the VAB on a launcher, complete with umbilical tower. The mobile launcher, together with its tower and the vehicle, will then be picked up by a huge, specially made crawler-transporter that moves on eight tank tracks. The crawler can negotiate slight inclines and make turns,

(Please turn to page 190)

MOBILE
LAUNCHER
AND PAD
MATING
OPERATION

LAUNCHER
GUIDE PIN

THREADED
BOLTS FOR
LOCK DOWN

72-IN.

MOVABLE
DISC

LOCKING
NUTS

LAUNCHER
MOUNT
MECHANISM

LAUNCHER
MOUNT
MECHANISM
(6 PER PAD)

SERVICE TOWER
MOUNT MECHANISM
(6 PER PAD)

FIREBRICK

EMERGENCY
EGRESS
SLIDE

SERVICE
STRUCTURE

CRAWLER
TRANSPORTER

EMERGENCY EGRESS SHELTER



MAN THE PUMPS, batten down the hatches—the author prepares for his first dive in a strange undersea craft

I BECAME AN AQUANAUT— THIRD CLASS

By DANIEL C. FALES

What's it like the first time down? Here's the tale of PM's outdoor editor, who took his maiden undersea voyage in General Dynamics' newest baby research sub

THE WORDS "Clear to dive!" shoot out at me as I stare at the hydrophone inches from my nose.

"Roger," intones Al Stover, pilot of *Star III*. I'm in a research submarine preparing to dive to the bottom.

This is my first undersea adventure. And I am not prepared for the eerie sights and sounds to come.

Star III is the newest mini-sub built

by Electric Boat Div. of General Dynamics. She's a sophisticated 23-foot version of two smaller subs in the Star class. She is 10 tons of exterior hull and pressurized cabin. Electric motors drive her at 4.5 knots underwater and 5 knots surfaced. She can carry 1300 pounds of "payload"—research instruments not designed as permanent fixtures. Other baby subs carry payloads



SWINGING FROM A CRANE, *Star III* is lifted from her support barge and swung overboard. Her pilot stands on the mini-sub during launch operations



COCKPIT INTERIOR shows hand-held control box at lower right. Large dials are depth gauges. Small round openings near floor are bottom-viewing ports

of only 300 pounds. (Editor's Note: The Russians say they want to buy *Star III* for research in the Black Sea.)

It was a bitter day when I arrived at EBD's dock in Groton, Conn. Ocean waves swept Long Island Sound, slapping against a huge barge that is the support "fleet" for *Star III*.

At first sight, *Star III* resembles a beamy orange and silver torpedo with a conning tower. This tower is called a sail, and is flooded when submerged.

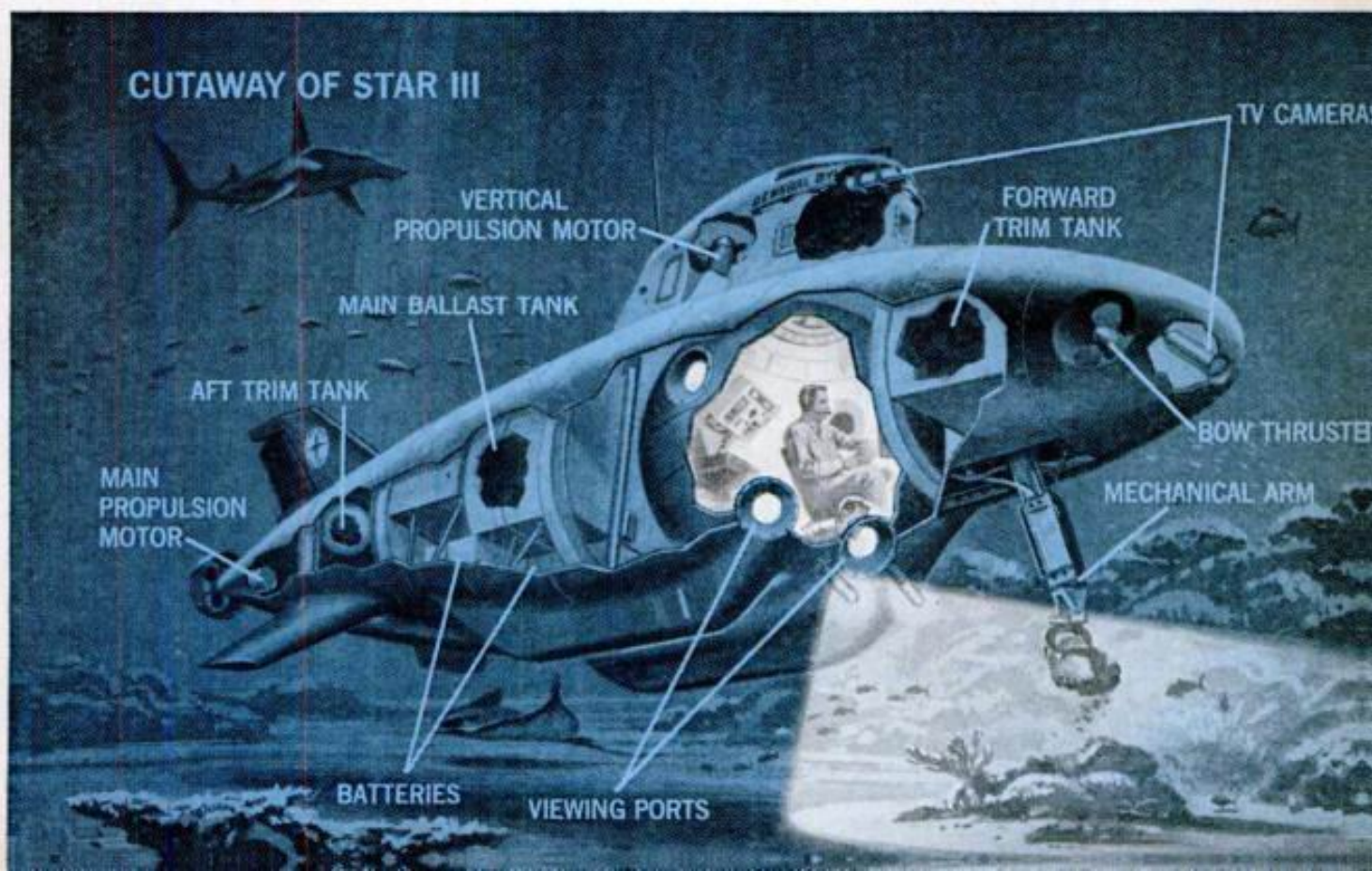
The water in the sail covers the only hatch into the cabin. Through this hatch I'd descended into the small, tight world of the pressurized hull.

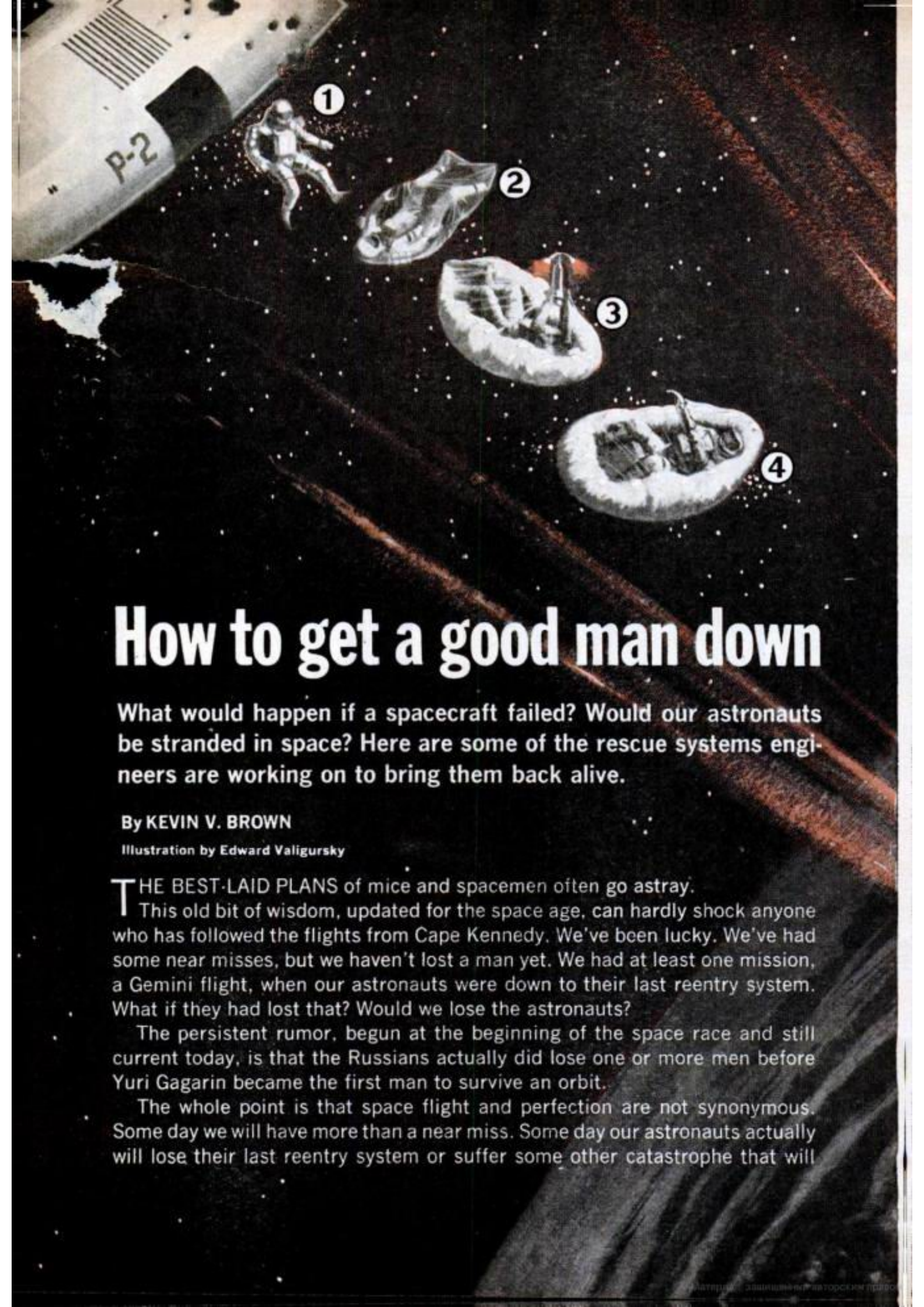
I'd dropped into the cabin like a circus performer loads himself into the muzzle of his cannon. Finally, I'd managed to adjust my body to the tight, cushioned seat on the port side.

My eyes are now scanning long banks of dials, toggle switches, meters and

(Please turn to page 198)

DRAWING shows interior compartments of craft. Mechanical arm can pick up samples or operate equipment



An illustration depicting a spacecraft rescue sequence in space. In the upper left, a portion of a spacecraft is visible with the label 'P-2'. Below it, an astronaut in a spacesuit is shown floating, labeled with a circled '1'. To the right, a small, transparent, capsule-like object is shown, labeled with a circled '2'. Further right, a larger, white, conical reentry vehicle is shown, labeled with a circled '3'. At the bottom right, another similar reentry vehicle is shown, labeled with a circled '4'. The background is a dark, starry space with some reddish-brown streaks.

How to get a good man down

What would happen if a spacecraft failed? Would our astronauts be stranded in space? Here are some of the rescue systems engineers are working on to bring them back alive.

By KEVIN V. BROWN

Illustration by Edward Valigursky

THE BEST-LAID PLANS of mice and spacemen often go astray.

This old bit of wisdom, updated for the space age, can hardly shock anyone who has followed the flights from Cape Kennedy. We've been lucky. We've had some near misses, but we haven't lost a man yet. We had at least one mission, a Gemini flight, when our astronauts were down to their last reentry system. What if they had lost that? Would we lose the astronauts?

The persistent rumor, begun at the beginning of the space race and still current today, is that the Russians actually did lose one or more men before Yuri Gagarin became the first man to survive an orbit.

The whole point is that space flight and perfection are not synonymous. Some day we will have more than a near miss. Some day our astronauts actually will lose their last reentry system or suffer some other catastrophe that will

1. In emergency, astronaut abandons damaged spacecraft after donning plastic escape suit like coveralls.

2. When zipped in, he initiates foaming process. Fed from two cylinders, foam fills bottom of bag.

3. Next, astronaut uses attached gunlike jets to orient escape capsule with foam-side toward earth.

4. When oriented, he fires reentry bursts from jets to place capsule into proper deorbit trajectory.

5. Now astronaut just rides package down. Foam protects him from heat and floats at splash down.

An illustration of an astronaut inside a small, white, conical escape capsule. The capsule is surrounded by a large, bright orange, flame-like or smoke-like cloud. The background is dark space with stars and streaks of light. The astronaut is wearing a white suit and helmet, and is looking out of the capsule's opening. The capsule is oriented with its base towards the viewer.

5



500 eggs in one basket

A revolutionary new era in air travel is only three years away. Then the first of the jumbo jets — with more than twice the capacity of present planes — will go into service. And even bigger “flying hotels” are in the works!



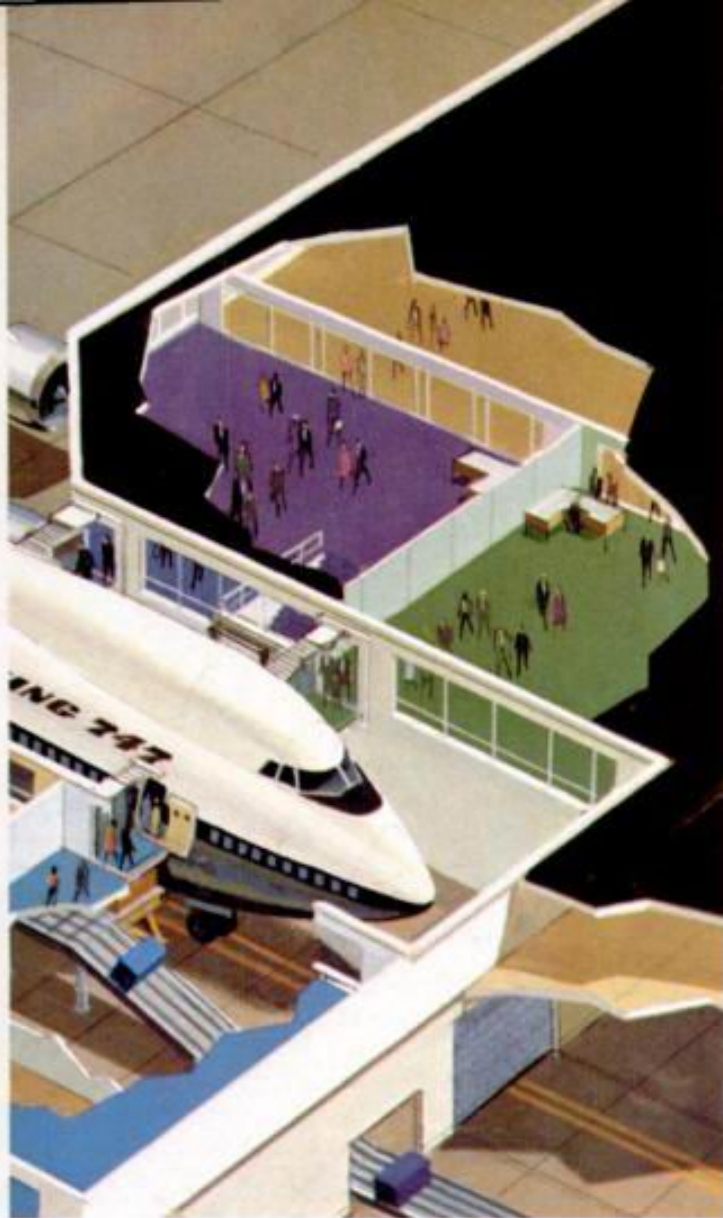
By THOMAS E. STIMSON

THEY'RE CALLING IT the “Boeing Hilton,” unofficially, because this enormous, new airliner will be able to carry 490 people, the capacity of a good-sized hotel.

There's room on board for private state-rooms plus a big lounge up forward. “Economy” seats will be large and luxurious. If an airline desires, the builder will

install a separate motion picture area and even a special playroom for children!

And here's the big surprise: Other builders are saying that Boeing's jumbo jets *aren't large enough!* Douglas is thinking about a 550-passenger DC-10 and Lockheed is talking about a gigantic L-500 that could carry from 750 to 900 passengers. Lockheed says its plane could fly



TO SPEED BOARDING, 490-passenger Boeing will require four waiting rooms, each with entrance to airliner. Speedy conveyors will carry aboard all baggage



SEATING CONFIGURATION for Boeing 747 calls for 9 or 10 abreast, but individual seats will be 10 percent wider than those currently used in the "economy" class



CONTAINERIZED CARGO in 10-foot-long boxes will roll on at rate of 100 tons—plane's capacity—in under 10 minutes. There will be both nose and side loading



HELICOPTER, MISSILE, TANK, JEEPS—typical cargo is shown aboard model of Lockheed C-5A. In commercial version, this plane could carry 750 to 900 passengers

you coast to coast for the price of a bus ticket, and make a profit. Or carry cargo at truck rates.

Pan American has ordered 23 of the new Boeing 747 airliners, plus a couple of cargo craft, and will put them into service beginning in three years.

In spite of their great size and weight, the new airliners will climb out faster than

the present jet transports. They will operate from existing runways. They will be able to fly higher, yet will be so sturdy that the present emergency oxygen systems for passengers may not be required.

They will be completely self-contained, with their own auxiliary powerplants to handle electrical requirements while on

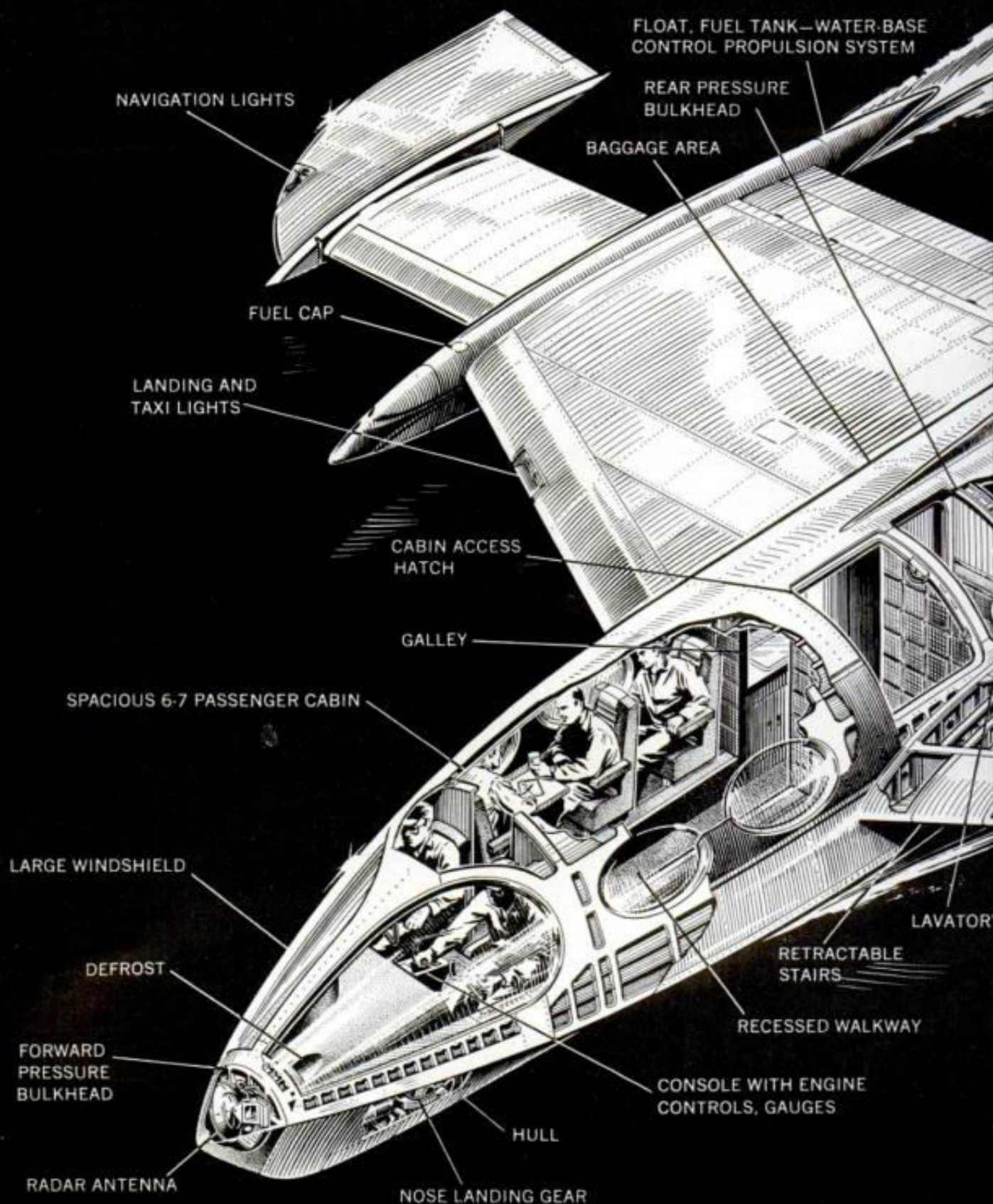
(Please turn to page 192)

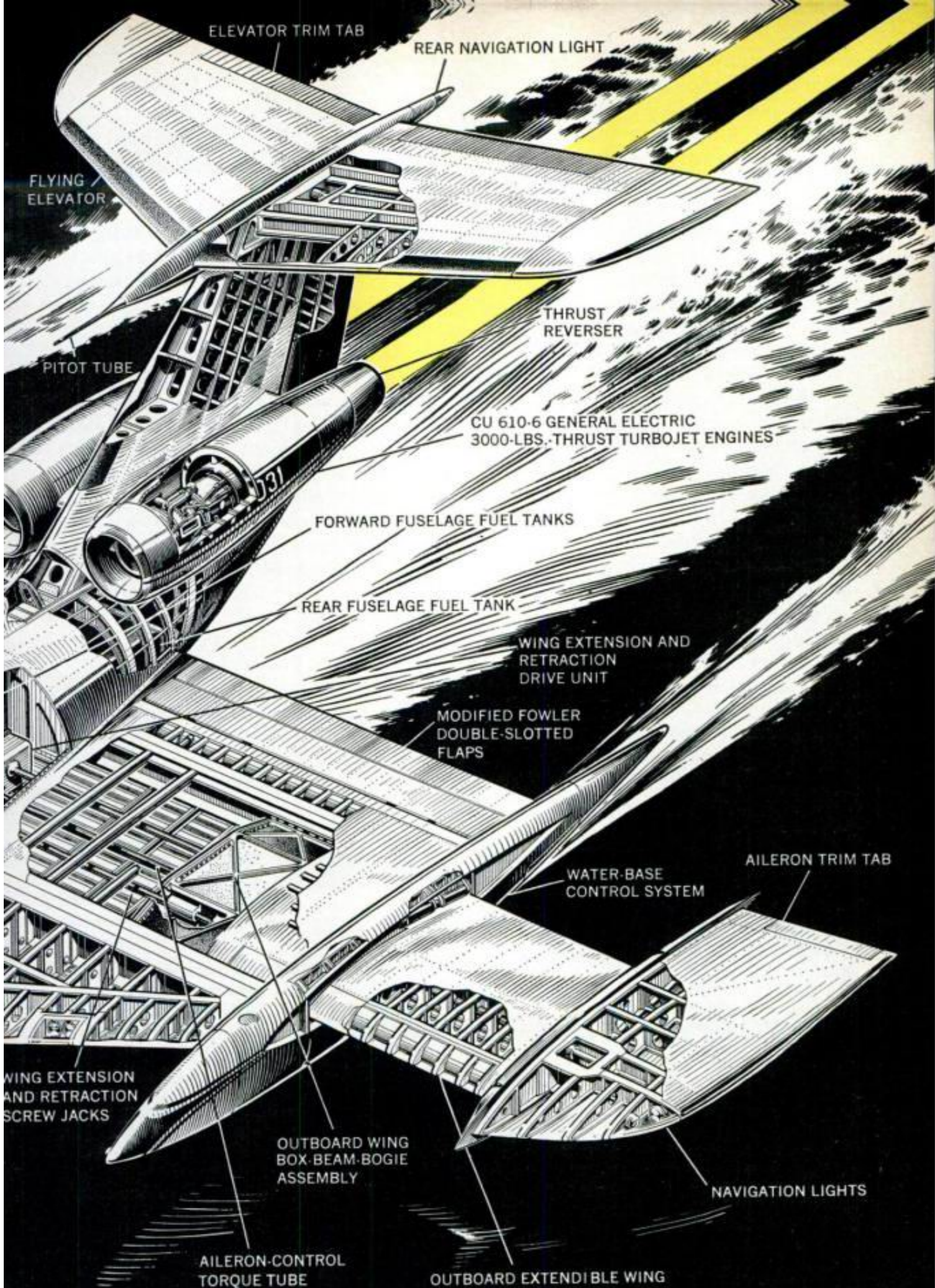
nels and being prepared for its first mockup. The concept is now stirring excitement among the flying fraternity throughout the country. And for a good reason: It's the first small jet designed to operate from land or water.

Skyshark is the brainchild of a Florida surgeon, Dr. G. Leonard Gioia of Merritt Island. The physician is an instrument-

rated pilot who flies his own Aztec and is something of an aeronautical engineer, to boot. He and two other men—Norris Switzer and John Willerton—have worked together for years to bring the new design through its engineering birth pains.

Switzer, who cut his teeth designing the P-40 fighter that the Flying Tigers used early in World War II, is a rocket





ELEVATOR TRIM TAB

REAR NAVIGATION LIGHT

FLYING
ELEVATOR

THRUST
REVERSER

PITOT TUBE

CU 610-6 GENERAL ELECTRIC
3000-LBS.-THRUST TURBOJET ENGINES

FORWARD FUSELAGE FUEL TANKS

REAR FUSELAGE FUEL TANK

WING EXTENSION AND
RETRACTION
DRIVE UNIT

MODIFIED FOWLER
DOUBLE-SLOTTED
FLAPS

WATER-BASE
CONTROL SYSTEM

AILERON TRIM TAB

WING EXTENSION
AND RETRACTION
SCREW JACKS

OUTBOARD WING
BOX-BEAM-BOGIE
ASSEMBLY

NAVIGATION LIGHTS

AILERON-CONTROL
TORQUE TUBE

OUTBOARD EXTENDIBLE WING

Technical Art by Fred Wolff

COMING...

The Incredible Skyshark—

First Amphibious Jet

By MARTIN CAIDIN, Author of *Marooned*

It's designed to cruise at 550 mph at 30,000 feet, operate from land or water bases and have STOL capability. Key to its revolutionary performance would be a telescoping wing.

LAUDERDALE TOWER, Skyshark One Six Alpha, number one, ready to roll. Over." The traffic controller in the airport tower studied the arrowhead shape through binoculars.

"Skyshark One Six Alpha, move into position and hold."

The sleek jet taxied onto the runway and stopped with its nose into the wind. Staring at the Skyshark, the tower operator nudged a colleague. "What is that thing?" he asked. He couldn't decide if it was an airplane or a futuristic speedboat. Far back on the fuselage behind raked wings were two jet engines beneath a swept-back, high tail. The nose appeared to be an expanse of plexiglass. He saw two pilots with a panoramic view of the world.

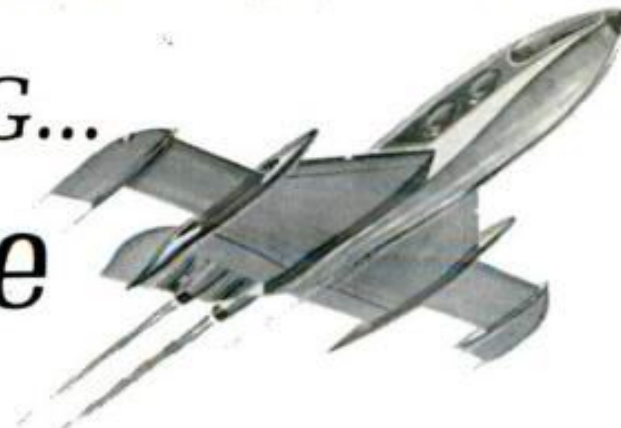
"I guess this is the first time you've seen one of those," the second tower operator said. "Ask him to make a max performance takeoff. Then hold on to your hat!"

The first man nodded. "Skyshark One Six Alpha cleared for takeoff," he said into the mike. "Would you mind showing us what the thing can do?"

"Roger, tower. Rolling now."

The men in the tower stared as the Skyshark sped down the runway. Then, only 600 feet from where it had started to move, the plane's nose came up. The gear snapped out of sight and the nose went higher, higher still, until the Skyshark was a dot in the sky.

This is a description of a takeoff that has yet to happen. Skyshark is now being tested in wind tun-



booster engineer at the Kennedy Space Center. Willerton, a pilot for 20 years, has helped to rebuild everything from old Spad fighters to modern jets.

These three men set their sights on a darn-near impossible goal. They wanted to build a business jet that could cruise at better than 550 mph, fly easily at 30,000 feet and, on long trips, fly nonstop for more than 2250 miles (with a 30-minute reserve), and carry eight people and baggage in comfort.

There are already about a half-dozen business jets with that kind of performance. But Skyshark, its designers decided, must do the same job with 40 percent less fuel consumption, and had to be able to lift off and land in one-fourth the distance required in standard takeoffs and landings. That wasn't all. The plane had to be able to out-climb any other business jet and be far stronger structurally. And it had to be able to do all this while operating as an amphibian.

It takes something special to produce such superior performance. That "something" is a variable aspect ratio wing—another Dr. Gioia brainchild. It's literally a wing within a wing.

For normal takeoff and landing or

WATER DEFLECTION AREA



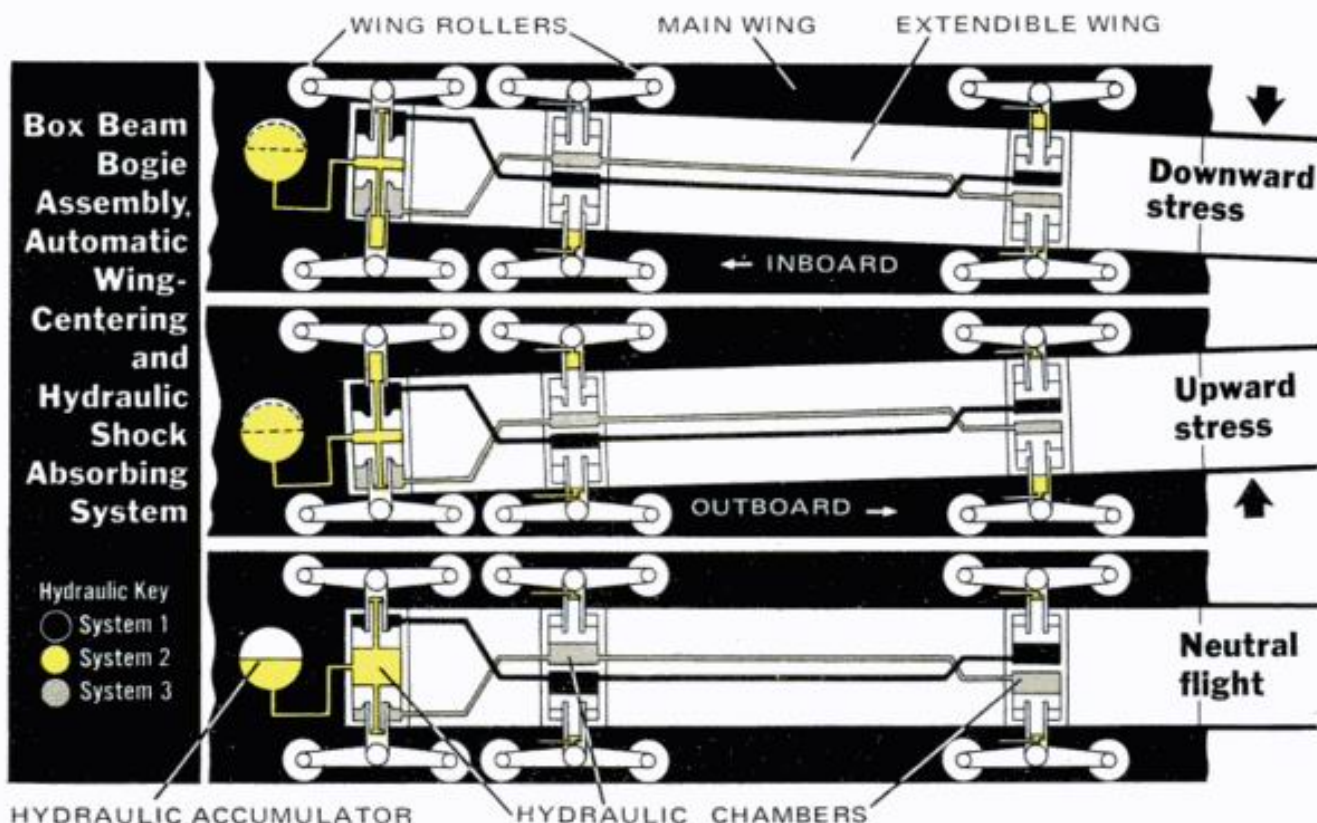
PROBLEM OF WATER DOUSING jet engines was met by making wings deep enough to provide protection

very slow flight, the wing is fully extended, increasing the span and greatly adding to the lift and control characteristics. For swift climb and rapid cruise with a minimum of drag, the wing retracts. Though the basic idea isn't new, the wing-control system developed by Dr. Gioia and his team is so new it's being patented. Not only does it allow for wing movement, it increases wing strength at the same time.

The key element in the system is a hydraulic mechanism that supports the inner (telescoping) wing. At the same time, the mechanism serves other critical functions such as absorbing shock, dispersing flight loads, damping flutter, increasing structural strength and improving flight characteristics.

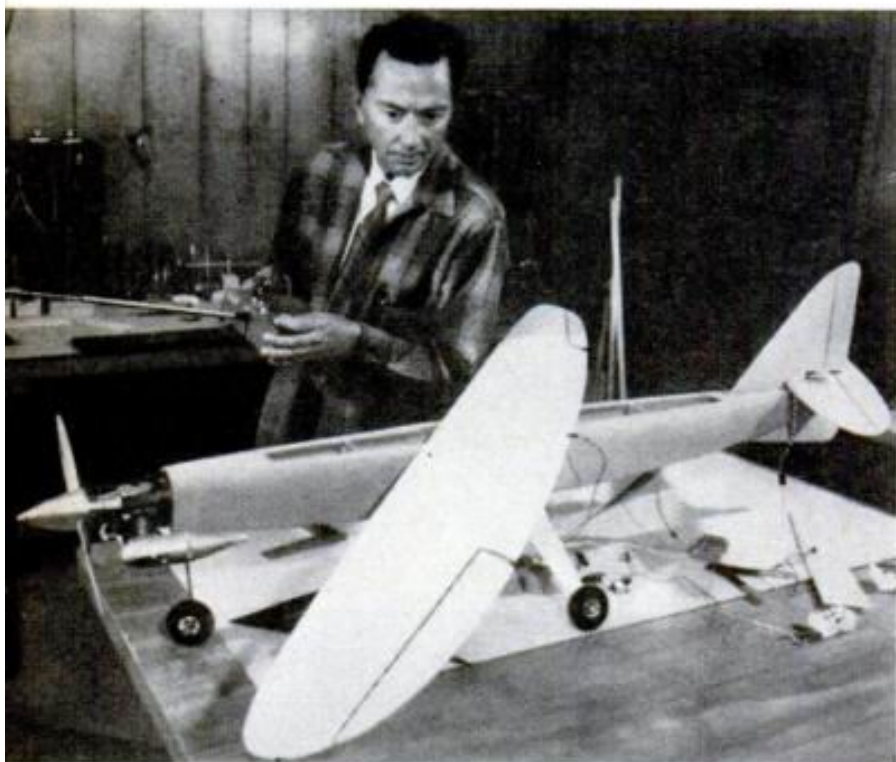
The STOL (short takeoff and landing) capability would make thousands of small fields available to business and private pilots. STOL would also make

(Please turn to page 180)



Those wild new wings: will they really fly?

Aircraft designers are having a field day trying shapes that look kooky, but may just be crazy enough to revive America's problem-plagued supersonic jet transport



ANTISYMMETRICAL WING pivots sideways in flight, giving the strange-looking craft the appearance of a pair of "flying scissors." Above is five-foot radio-controlled model built by NASA inventor Dr. Robert T. Jones to help test out wing's principle. How idea works is shown on facing page. Because opposing wing and tail surfaces are offset, they don't "fight" each other with their turbulence. This reduces drag, lowers power needs and permits supersonic speeds without producing a dangerous "sonic boom." For low-speed landings and takeoffs, the wing and tail swing back to conventional straight positions

IT LOOKS LIKE a flying mistake. At high speeds, its centrally pivoted wing and tail surfaces turn sideways at a 45° angle to the fuselage, giving the craft the freakish appearance of a pair of flying scissors. At low speeds, the wing and tail swing back to a straight-across position like those on a conventional airliner.

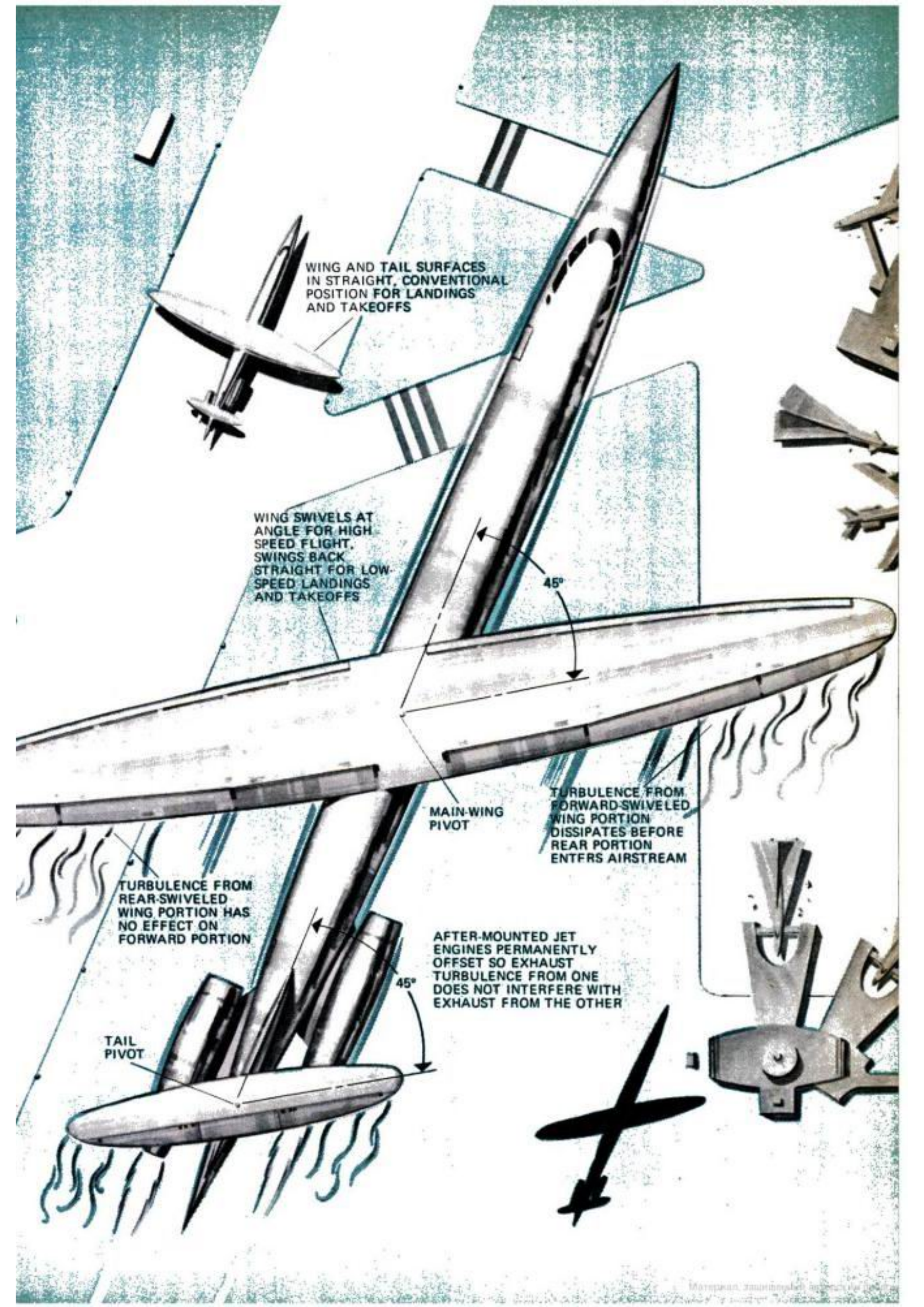
But the "antisymmetrical" design, as it is called, is no freak. As strange as it may look in flight, this radical new aircraft has proven so successful in tests that it may be just what is needed to revive America's foundering supersonic transport program, officially killed by Congress in 1969 because of strong objections to then-current SST proposals.

Developed by Dr. Robert T. Jones, senior staff scientist at NASA's Ames Research Center in Mountain View, Calif., the weird antisymmetrical concept is designed to provide the high speed of supersonic jet travel, while still maintaining the advantages of low-speed subsonic flight. The problem, says Doctor Jones, is that we've always assumed wings had to be symmetrical because man's flying machine was originally patterned after nature's—the bird. "But there are no supersonic birds," he points out.

Supersonic flight requires a whole new approach because odd things happen at supersonic speeds that don't at lower speeds. At subsonic speeds, advancing shock waves "warn" the air ahead that a plane is approaching, and the air starts to part to let it through. These shock waves travel at exactly the speed of sound. At sonic speeds, the air ahead gets no advance warning since the plane is traveling at the same speed as its own shock waves. The craft thus slams into the unprepared air like a solid wall, generating much more violent shock effects. These shocks cause heavy drag-producing turbulence that saps engine power and triggers

By WALTER B. HENDRICKSON JR.

POPULAR MECHANICS



WING AND TAIL SURFACES
IN STRAIGHT, CONVENTIONAL
POSITION FOR LANDINGS
AND TAKEOFFS

WING SWIVELS AT
ANGLE FOR HIGH
SPEED FLIGHT.
SWINGS BACK
STRAIGHT FOR LOW-
SPEED LANDINGS
AND TAKEOFFS

45°

MAIN-WING
PIVOT

TURBULENCE FROM
FORWARD-SWIVELED
WING PORTION
DISSIPATES BEFORE
REAR PORTION
ENTERS AIRSTREAM

TURBULENCE FROM
REAR-SWIVELED
WING PORTION HAS
NO EFFECT ON
FORWARD PORTION

AFTER-MOUNTED JET
ENGINES PERMANENTLY
OFFSET SO EXHAUST
TURBULENCE FROM ONE
DOES NOT INTERFERE WITH
EXHAUST FROM THE OTHER

45°

TAIL
PIVOT



ENGINEERING

First Look at the

By MORT SCHULTZ

Illustration by Roy Grinnell

5-INCH GUN

HELICOPTER PAD

HANGAR

MOTOR LAUNCH

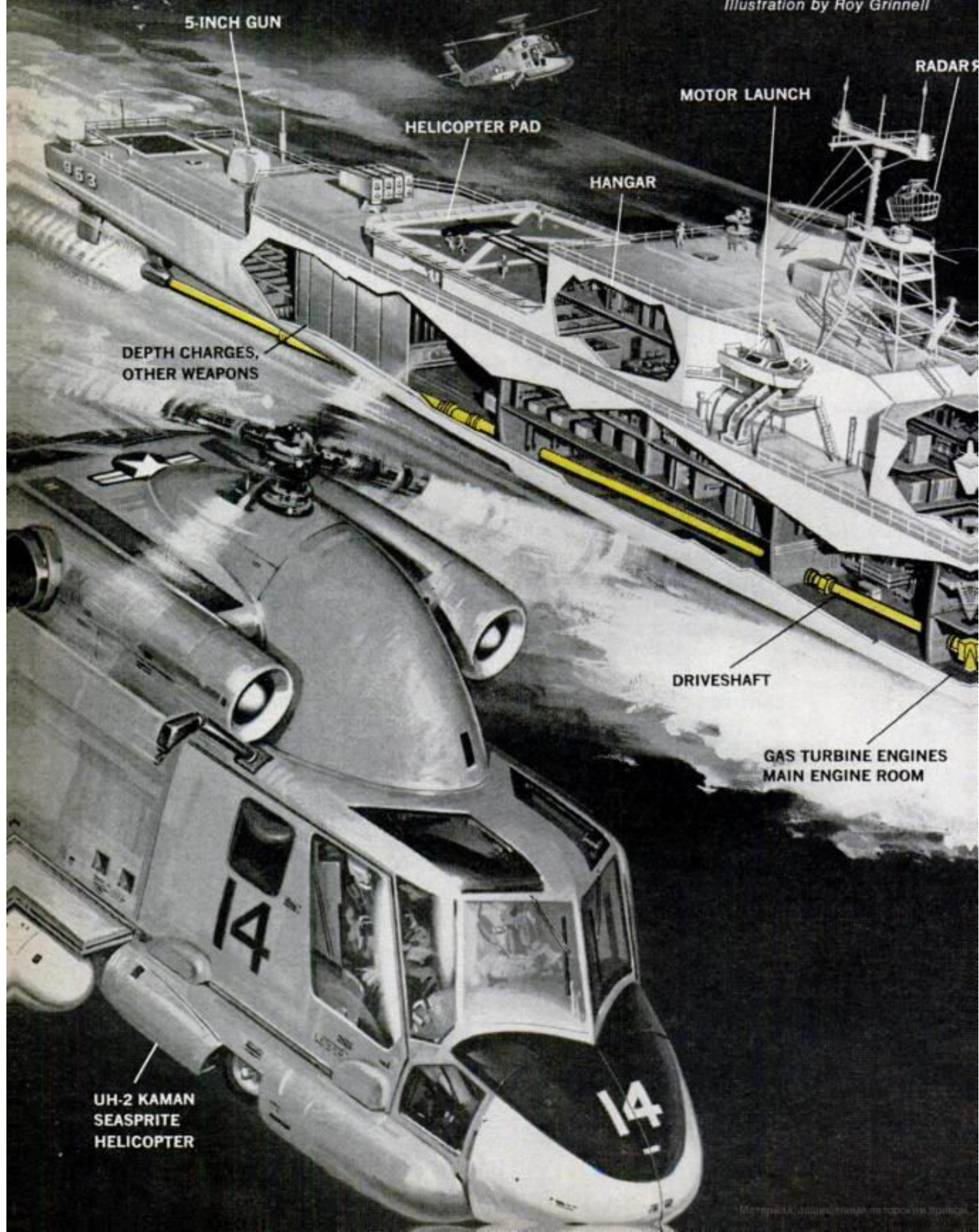
RADAR

DEPTH CHARGES,
OTHER WEAPONS

DRIVESHAFT

GAS TURBINE ENGINES
MAIN ENGINE ROOM

UH-2 KAMAN
SEASPRITE
HELICOPTER



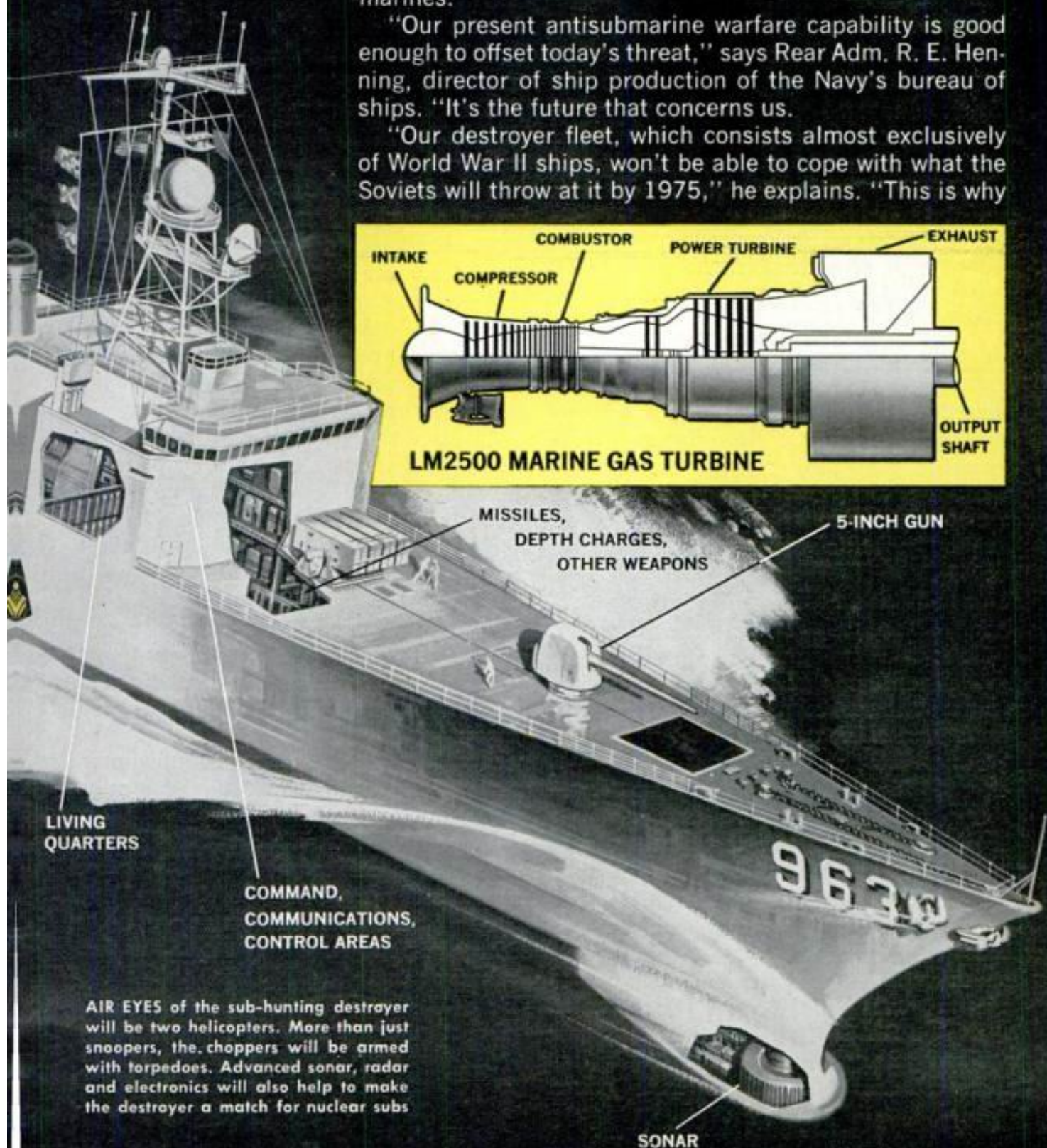
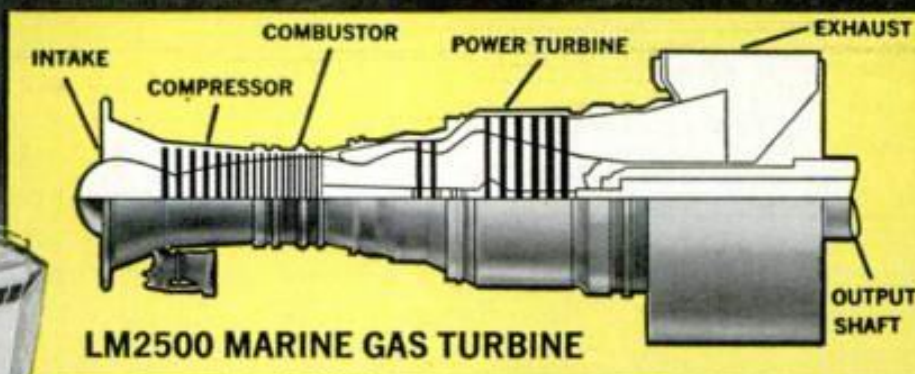
Navy's New Destroyer

The quietest ship in the fleet will have long eyes—her own helicopters; big ears—advanced underwater surveillance gear; and a mighty punch—rocket-assisted torpedoes that home on enemy subs.

THEY WON'T BE LAYING THE FIRST PLATE for the DD-963 until early in 1973, but the new destroyer will be ready in time to counter the growing threat of Soviet submarines.

"Our present antisubmarine warfare capability is good enough to offset today's threat," says Rear Adm. R. E. Henning, director of ship production of the Navy's bureau of ships. "It's the future that concerns us.

"Our destroyer fleet, which consists almost exclusively of World War II ships, won't be able to cope with what the Soviets will throw at it by 1975," he explains. "This is why



AIR EYES of the sub-hunting destroyer will be two helicopters. More than just snoopers, the choppers will be armed with torpedoes. Advanced sonar, radar and electronics will also help to make the destroyer a match for nuclear subs

COVER STORY



Packed with technology, *Deep Flight* (above) will blaze trails for more conservative, twin-pilot *Ocean Everest* craft (opposite). Shared innovations include exoskeletons containing jettisonable people pods and high-speed hydrodynamic maneuverability, provided by aft control surfaces.

DEEP FLIGHT

Soaring like an airplane thousands of feet down, a radical new sub will test technology for the next assault on the ocean's greatest depths.

BY GREGORY T. POPE; PM Illustration by Attila Hejja



THIRTY YEARS AGO, U.S. Navy Lt. Donald Walsh and Swiss oceanographer Jacques Piccard squatted in a 50-ton steel cocoon, looking for the first time at the bottom of the world. After a 4½-hour plunge, the Navy's bathyscaphe *Trieste* touched down at the base of Marianas Trench, 38,520 ft. below the Pacific, then began a 3-hour ascent to the surface. Since that day, January 23, 1960, no one's been back.

Now there's talk of sending submariners to the Trench again. Only this time they're not going to sink to the bottom—they're going to fly.

A man who's already cut a maverick reputation in the ocean engineering world is building what he calls the world's first underwater aircraft. As early as this fall, *Deep Flight I* and *II* will wing their way through the depths as technology demonstrators for a future Trench-diving craft. Graham Hawkes, the craft's designer, likens *Deep Flight's* departure from normal sub design to the difference between airplanes, which use aerodynamic lift to soar, and balloons, which use buoyancy and ballast to rise and fall.

"Think of them like NASA's experimental planes, like an X-1 or an X-15," he says, "in which they'd take aspects of flying and push them as far as possible." And Hawkes and his wife, marine biologist Sylvia Earle, will be the Chuck Yeagers of the seas, the first to pilot the twin *Deep Flight* subs.

But unlike a federally funded X-plane, *Deep Flight* is coming to life at night, on a shoestring budget, in the

hands of Hawkes and a crew of nine volunteers. They gather after working hours at the San Leandro, California, headquarters of Deep Ocean Engineering, Inc., a company cofounded by Hawkes and Earle in 1982. The cavernous subsea-robot manufacturing plant is littered with half-built remotely operated vehicles, fiberglass mandrels and machine tools.

Overseeing the work is Hawkes, an owlish 40-year-old Briton known best for his *Deep Rover* (see "Conquering Our Deepest Frontiers," page 86, Jan. '85), the bubble-shaped submersible, in which Earle and Hawkes set solo diving records of 3000 ft. three years ago. A decade in the San Francisco Bay area has tempered Hawkes' accent, but honed his drive to be different. "Part of this project is simply mischief, you see," he admits. "There's been so little innovation in the field, so little cross-fertilization between military and commercial submersibles. We're trying to stir things up."

In fact, he's throwing every innovation he can into *Deep Flight*. Each craft fairly bristles with technology. To strengthen the flight analogy, for example, Hawkes has plucked components from aircraft, such as an F-16's force input joystick, fly-by-wire electronics, a parachute-style restraint harness and low-weight, high-strength composite materials.

Barrel rolls with the whales

But the outsized rear control surfaces are what makes *Deep Flight* take off from conventional sub design. Jet-

DEEP FLIGHT

tionizing the concept of variable ballast for depth control, Hawkes is building *Deep Flight* to dive and ascend hydrodynamically like a sound-impinging dolphin, the control surfaces determining pitch. The mid-hull wings are cambered like upside-down airfoils to provide a reverse lift. Since the sub is positively buoyant, it will enter an unpowered glide to the surface if propulsion fails.

What's more, the craft will pitch and roll through 360°. "Hydrobatic" is a favorite Hawkes coinage—another of his pet phrases is "doing barrel rolls with the whales at 4000 ft."

The pilot will lie in a pressure-resistant people pod, a thick fiberglass tube with a transparent acrylic viewport on one end. Nylon straps secure the pod to its exoskeleton, a free-flooding framework equipped with wings, propulsion, control surfaces and batteries. Exoskeletons will interchange, like suits of armor. Some will be built for speedy search and survey missions, others outfitted with sensory-feedback manipulators for detailed recovery work. If sea-floor detritus snares the exoskeleton, the pod can eject and float free.

The exoskeletons now under construction each house two thrusters that can push the craft along in 15-knot bursts. Underwater cruise speed will be a brisk 12 knots, and maximum dive and ascend speed a heady 600 ft. per minute.

Behind this subsurface muscle are twin pods of powerful aluminum-oxygen batteries. Scaled up from units that power emergency-buoy beacons, the batteries are simply rows of aluminum plates that touch off a strong current when doused in seawater. The AlOx pods, which can't be recharged, are detachable and won't be used for training and short trips. On-board reusable lead-acid gel batteries back up and buffer the AlOx power.

Also a factor in *Deep Flight*'s nimbleness is lean construction. Fiberglass, impregnated with syntactic foam in the pilot's pod, has replaced metal for all structural components, and results in a sub weighing only 1½ tons.

Preparing for launch

Deep Flight's light weight will free it from the need for a dedicated mother ship, and it can even deploy via helicopter. Preparation will be a simple routine. The acrylic dome will be rolled out on its internal track assem-

bly, pilot will crawl in backward, and the dome racked back into place and sealed with a rubber O-ring. Then, the shipboard crew will test the hull's integrity by dropping pod pressure to ¼ of an atmosphere. Lying prone as *Deep Flight* flies the deep, the pilot will grasp the joystick with one hand, while the other holds a secondary grip with camera and light switches. Once



Hawkes models his partly assembled creation (top). The craft is being assembled by an all-volunteer crew, two of whom are shown above with Hawkes.

on a suitable course, the pilot can put the craft on autopilot while he attends to instrumentation, or just enjoys the view.

Voyage to the bottom of the sea

Should *Deep Flight* live up to its name, many of its features will be inherited by *Ocean Everest*, a dual-pod, bottom-diving craft that remains on the drawing board. *Ocean Everest* will be more conservative in design because, unlike *Deep Flight*, it must be insurable and ABS-certified, so that Hawkes can sell production models to the U.S. Navy and research organizations.

Ocean Everest will meld *Deep Flight*'s innovations with more traditional sub features. Although the large rear control surfaces will remain, vertical thrusters will be added, allowing the craft to hover in place. The acrylic domes—cast from transparent ceramic—will be hemispherical to better distribute water pressure. Perhaps the only breakthrough on *Ocean Everest* will be the pods' thick-wall graphite-composite material, which is capable of rebuffing nearly 30,000 psi, giving a 2:1 safety factor at full ocean depth.

The resulting unlimited depth capability, along with its 12-knot speed, will put *Ocean Everest* at the pinnacle of submersible design—and in great demand. Right now oceanographers have a scant handful of deep-diving submersibles. None go deeper than about 20,000 ft., and all are hampered by sluggish subsurface speeds and the need for a dedicated mother ship.

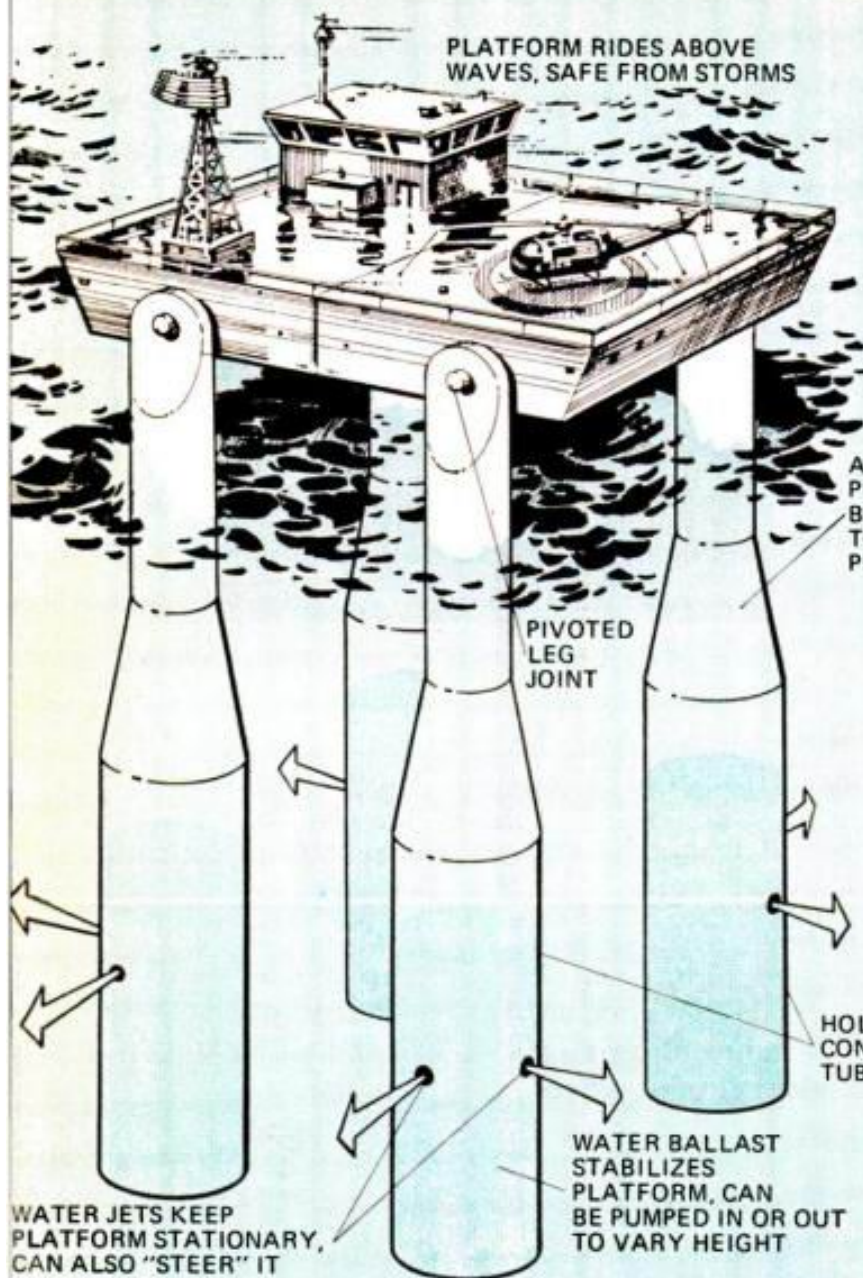
"The tools we have," says Grant Gross, director of the National Science Foundation's ocean sciences division, "are functionally underwater elevators. Something like *Deep Flight* would open up avenues that we simply have not had."

Even as shallow as 4000 ft., Gross explains, ½-knot craft like Woods Hole's *Alvin* cannot keep up with the organisms under investigation. "Squid, whales, tuna, mackerel—just about anything can outswim a submersible," agrees Earle.

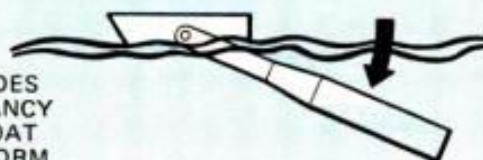
At greater depths, Gross says, the ability to survey much broader areas represents "an order of magnitude improvement in technology." *Ocean Everest* would open up detailed investigation of depths below 12,000 ft., which account for about 40 percent of the ocean's total volume. Even below 20,000 ft. lie areas, all unexplored, adding up to the size of the United States. "We should be thinking about setting aside areas of the ocean for various levels of protection," says Earle. "One thing we can do with a high-speed craft like *Deep Flight* is to scout and make knowledgeable decisions about protection."

But beyond conservation missions, Earle agrees with Hawkes that the "sheer joy of *Deep Flight*" will make the project worthwhile. "To be able to go swiftly through water in a vehicle that's more like a suit of clothes," says Earle, "will give a diver a new, intimate kind of relationship with the ocean." **PM**

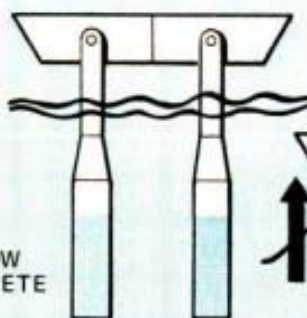
Man-made 'island' floats



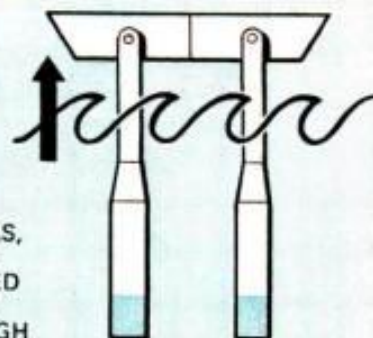
- 1 PLATFORM SECTIONS ARE TOWED OUT TO SEA WITH PIVOTED LEGS TRAILING OUT BEHIND



- 2 LEGS ARE FILLED WITH WATER AND SUNK BELOW PLATFORM



- 3 SECTIONS ARE JOINED TOGETHER AND THE LEGS PARTIALLY PUMPED OUT TO RAISE PLATFORM ABOVE SURFACE



No-tilt forklift

Top-heavy forklift trucks often tip over if they tilt on a grade (photo at far left), killing or injuring their operators. To eliminate the hazard, two British inventors, Joe Haley and Ron Grice, have come up with a forklift that pivots. No matter in which direction the truck wheels tilt, the lift itself will remain vertical (near left) so it can't topple over. The hydraulic controlled forklift trucks are made by TFL Crane, Ltd., Great Gransden, Bedfordshire, England.

POPULAR MECHANICS



JET SHIPS

By replacing propellers with superconducting magnets, jet ships may one day ply the seas at 100 knots.

BY ABE DANE, Science/Technology Editor; PM Illustration by John Berkey



CARGO HOLD

SUPERCONDUCTING MAGNET CLUSTER

AVAST SHAPE darts beneath the polar ice flows, and is gone, as silent as a living creature, but far swifter. Clad in steel, and traveling at over 100 miles per hour, it leaves only a mistlike trail of bubbles in its wake. There are no great screws or turbines churning the water. In fact, there is no sign of any sort of propulsion system at all. Instead, the huge underwater freighter is thrust through the depths by an invisible force generated by water rushing through tubes enclosed in sponsons at the submarine's sides.

Futuristic as it sounds, the force powering this craft is actually so basic it is taught in high school science classes. Called Fleming's Left Hand Rule, this fundamental of electromagnetism states that the confluence of a magnetic field and an electric current passing through a fluid will cause the fluid to be propelled in one direction. It was not until recently, however, that the

technologies existed to harness this phenomenon aboard a seagoing vessel. Now, in laboratories in Japan and the United States, systems known as magnetohydrodynamic (MHD) drive units are putting the Left Hand Rule to work in small models and experimental flow loops. The military is rumored to have been pursuing MHD research for years, to the point where an MHD drive played a key role in "The Hunt For Red October," a movie produced with unprecedented U.S. Navy cooperation and based on Tom Clancy's meticulously researched novel.

Japanese superships

Although the concept was first put forth in a 1961 patent by American scientist W.A. Rice, it is the Japanese who have made the greatest strides toward producing a practical MHD drive in the nonclassified world. A \$40-million program funded by the Japanese Foundation for



Based on a JAFSA concept, a future subsea freighter carries cars from Japan to Europe under the polar ice cap.

NUCLEAR POWERPLANT

Shipbuilding Advancement (JAFSA) has produced a fully operational model 2 meters long. And this summer, they plan to launch a 150-ton, 90-ft.-long seagoing vessel called the *Yamato-1*.

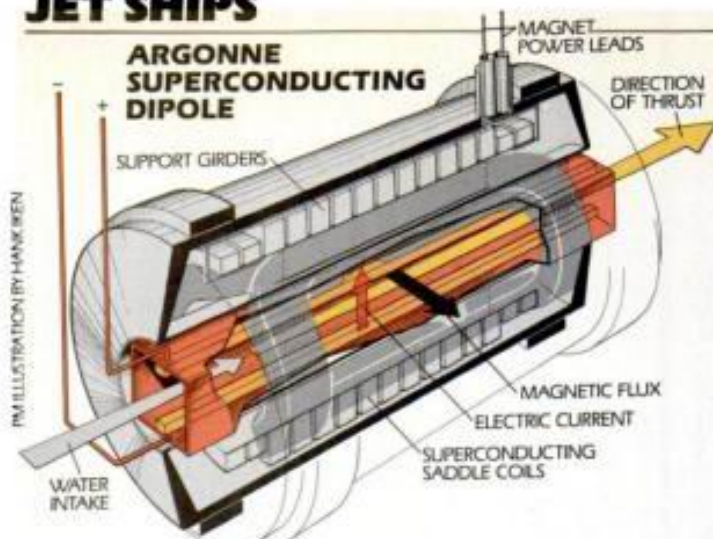
Although this early design is expected to be capable of only 8 knots, and with relatively poor efficiency, MHD has the potential to excel in both these areas. "We don't have to worry about cavitation of propellers with the MHD system. Therefore, there is no limit on speed," says Dr. Michael Petrick, who oversees MHD research at the Argonne National Laboratory in Illinois. The Japanese predict MHD vessels will one day be able to travel from Yokohama to San Francisco in three days. Efficiency is potentially very high as well, increasing in proportion to the square of the intensity of the magnetic field. Thus, the success of MHD depends on the development of extremely powerful magnets light enough to be carried aboard a ship.

Progress in this area has surged ahead, thanks to improvements in superconducting materials that can be formed into the coils of electromagnets. And a quantum leap in affordability is on the horizon, if a way can be found to use new high-temperature yttrium-barium-copper oxide superconducting materials that could be cooled with liquid nitrogen, instead of expensive and difficult-to-handle liquid helium.

Power packages

As more compact, powerful and efficient magnets become available, the challenge shifts toward integrating them into a complete propulsion plant, incorporating cryostats to keep the magnets at superconducting temperatures, and a power supply to feed the magnets and charge the electrodes that pass the current through seawater. The Japanese have tried two basic approaches. The simplest is to install a powerful superconduct-

JET SHIPS



Argonne superconducting dipole (right) crisscrosses lines of magnetic flux and electric current to produce thrust (left).

ing magnet pointed straight down through the ship's bottom. Current from electrodes on the hull interacts with the magnetic field in the open water surrounding it. Although simple and efficient, this arrangement would cause tremendous magnetic disturbances that could interfere with sealife and other shipping.

Thus, JAFSA has embraced a more complex approach. *Yamato-1* will be powered by two jet pods slung along the underside of the vessel. Each pod will contain six cylindrical superconducting dipole magnets arranged in a ring around a central support. Water is drawn in through the front of the pod, and propelled through electrically charged ducts running through the center of each magnet, then jetted out the back. Reversing propulsion direc-

tion is as simple as reversing the current in the ducts.

Big American magnet

"The Japanese are using smaller magnets, but clustering them like the old days of clustered rockets," says Dr. Petrick. By contrast, the Argonne effort is focused on the largest superconducting dipole magnet in the world. Weighing about 200 tons, the magnet, which was originally built for experiments in electric power generation, is far too large for maritime use. The point of the Argonne research, however, is to learn about the effects of extremely powerful magnetic fields with an eye toward the day when such fields will be available from smaller magnets. "Our program provides an opportunity to leapfrog

the Japanese in the scale and magnetic field strength of the MHD experiments," says Dr. Petrick.

Focused as they are on the electromagnetic phenomena at the heart of MHD propulsion, the Argonne team is making no effort to build a complete prototype propulsion system. Instead, they are placing the magnet in a 4-ft.-dia., 60-ft. x 25-ft. water loop—a sort of aquatic dynamometer that will let them scrutinize the magnet's performance in oceanlike conditions, without leaving the lab.

The jet age

If these experiments prove fruitful, Dr. Petrick sees a variety of uses for MHD systems on the horizon. They are already in use as pumping systems for the liquid-metal coolants used in some nuclear reactors. More exciting, of course, is the technology's potential in the area of shipping. Not only is there the advantage of high speed and great efficiency, but the lack of moving parts would also reduce maintenance. What's more, eliminating the need to link the power source with the propulsion system by a shaft or other mechanical means makes radical new hull configurations possible. JAFSA has produced a number of wild-looking concepts, including an airliner-shaped cargo submarine, and small waterplane hull (SWATH) passenger ships that ride on pairs of submerged pods containing MHD drives. Cargo submarines are a particularly intriguing possibility, according to Petrick, "because they would have less drag than surface vessels and could descend to avoid storms. Also, vessels used in marine biological research could benefit from quieter designs that would be less disruptive to sealife."

These and other possibilities continue to spur research that may one day make the propellers as obsolete as they once made the sail.

PM

Tom Clancy's Caterpillar

ENGAGE THE caterpillar," says Sean Connery, playing the grizzled veteran of the Soviet submarine corps, who captains the *Red October*. With that, the top-secret Soviet missile sub vanishes from the sonar monitors of the American attack sub *Dallas*, which has been shadowing her a few ship lengths behind.

The caterpillar is an MHD drive system running up the center of *Red October's* hull, and, like most of the fascinating morsels of technology in the film, it is an idea with at least some basis in reality.

But would an MHD-propelled sub really be undetectable? The short answer is: Probably not.

Capt. James H. Patton Jr., a retired U.S. Navy sub commander who served as a technical consultant during the making of the movie "Red October," says he sees MHD as intriguing, but fraught with problems from a military standpoint. Although an MHD drive system could indeed be very qui-



Actor Sean Connery as Capt. Marko Ramius at the con of the *Red October*.

et, and, thus, might thwart passive sonar arrays like those aboard American attack subs, the tremendous magnets would produce stray fields that would be relatively easy to pick up. Also, electric current running through the seawater would electrolyze it, producing a traceable trail of gas bubbles, particularly chlorine.

Still, the Navy will follow MHD research with interest. "Any self-respecting naval lab has looked at it," says Patton. "People keep their finger on the pulse."

—A.D.

SEPTEMBER 1990 \$1.95

Popular Mechanics

GIANT SKY FREIGHTERS

Hydrogen Will Power 2-Million-Pound
Planes Over 16,000 Miles Without
Refueling



DEATH VALLEY TO PIKES PEAK
FORD EXPLORER TORTURE TREK

BUILD YOUR OWN ELECTRIC GUITAR

Challenge Your
Woodworking Skills

FUTURE PICKUPS GO RADICAL

Next-Generation
Trucks Will Be Wild

CRANK UP YOUR AUTOSOUND SYSTEM

Add-Ons To Get
Big, Full Sound

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THE HYDROGEN AGE

As oil dwindles and environmental dangers mount, hydrogen is emerging as a likely candidate to be our power source of the future.

BY ABE DANE,
Science/Technology Editor

AT ONE END of a 3-mile corridor of pavement in the Mojave Desert, a dartlike plane the size of a small jetliner is readied for flight. With only minutes until ignition, a potent slurry of super-cooled hydrogen rushes into its fuel tanks. And two pilots monitor an endlessly rehearsed sequence of events that is gradually bringing the craft to life.

The tanks fill. The plane settles on its landing gear, burdened by a load of hydrogen three times its weight. Packing three times the power per pound of Jet-A kerosene, the hydrogen will combust in a row of rectangular ramjet/scramjet engine modules under the rear of the radically swept delta wing. The resulting thrust will propel the plane to 25,000 mph, and fling it into orbit.

The year is 1997. The National Aerospace Plane, the X-30, is on the flight line for the first time. In itself, it is an achievement on the order of the *Apollo* spacecraft. But it also represents a whole family of technologies with the potential to work profound changes on our daily lives.

The tie that binds these technologies together is hydrogen. Today,



Early Lockheed concepts for future freighters provided large fuel storage spaces for lightweight, high-power hydrogen.

even as work goes forward on propulsion systems and new materials for the X-30, quieter advances are being made toward the development of an infrastructure that would bring the fuel of spaceflight home, ending our dependency on dirty and dwindling fossil fuels.

Future fuel

At the heart of hydrogen's promise lie two key qualities. First, supplies of it are virtually limitless. Since it is a primary constituent of water, an economical method of extracting it is the only thing needed to produce literal oceans of energy. Second, burning hydrogen does no harm to the environment. It simply returns the gas to the form of water.

Hydrogen is also a uniquely flexible

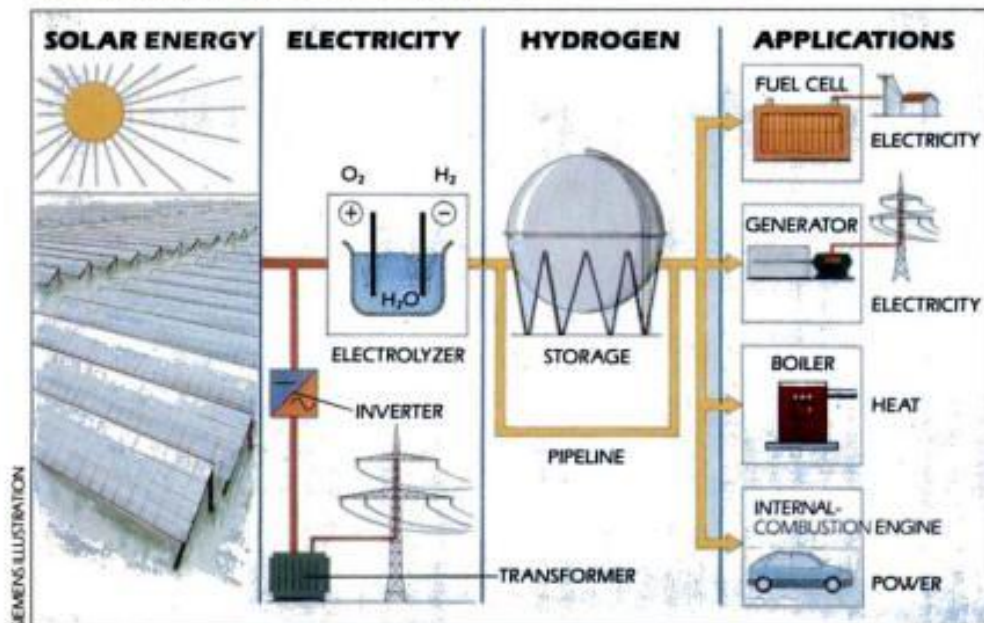
medium for the storage and distribution of energy. It is easily converted into electricity through the use of a fuel cell, and electricity can be turned back into hydrogen by electrolyzing water. Transmitted through pipelines similar to those used for natural gas, it can carry energy from large, remote powerplants to individual homes and factories as electricity now does—but with far greater efficiency. And unlike electricity, hydrogen can be kept in tanks to fuel vehicles, or to store power for periods of peak demand.

In the words of Peter Hoffman, editor and publisher of *The Hydrogen Letter*: "Hydrogen is the fuel at the end of the line when everything else has been depleted, found unworkable or environmentally objectionable."

Stumbling blocks

To most people, the word hydrogen immediately conjures up the specter of the *Hindenburg* dirigible, exploding over the New Jersey countryside. Yet, a more objective analysis reveals that hydrogen is no more dangerous than other flammable materials used as fuels, and even has some significant safety advantages. Ironically, a case in point is the *Hindenburg* incident itself. Although it exploded hundreds of feet off the ground, 62 of the air-

THE HYDROGEN AGE



Scheme for a future energy economy uses electricity from solar panels to electrolyze water into hydrogen for storage and pipeline transmission, and then for a diverse range of applications.

ship's 97 passengers survived, partly because the lightweight gas rose clear of the craft as it burned, and was consumed in a relatively brief explosion. Kerosene jet fuel would have clung to the wreckage and burned furiously for a long time, likely killing everyone in the vicinity. Still, the *Hindenburg* remains a real obstacle to hydrogen's acceptance among the general public.

From a practical point of view, however, the real problems have to do with engineering and economics. For decades, hydrogen has presented researchers with a tantalizing combina-

tion of promise and impracticality. Efforts to use it as an aviation fuel, where its light weight would be especially useful, stretch back to the 1950s, when the Air Force ran one engine of a B-57 Canberra bomber on the fuel in preparation for a proposed effort to run a supersonic version of the U-2 spyplane on hydrogen. The project was scrapped not for technical reasons, but because of the prohibitive cost of outfitting airports around the world with hydrogen fueling stations. "It's a beautiful fuel for turbines," says Willis Hawkins, a retired

Lockheed engineer who worked on the program.

Subsequent projects have amply demonstrated the feasibility of using hydrogen to power aircraft, home appliances, cars and everything in between. But these uses haven't caught on for reasons similar to those that killed the ill-fated U-2 project.

Accelerating progress

Before the impasse can be overcome, more efficient ways must be found to produce hydrogen, handle it and burn it. Research has been sporadic. Over the years, however, knowhow has accumulated in diverse and seemingly unrelated fields which, when taken together, adds up to a considerably brighter outlook for hydrogen. Examples include:

■ **Steady improvements in the cost and efficiency of amorphous silicon photovoltaic cells**, which could power electrolyzers that split water into hydrogen and oxygen. An exhaustive study completed last year at Princeton University predicts that around the year 2000, it will be economical to convert solar energy into hydrogen.

■ **New storage mediums based on superactivated carbon** that can hold 7- to 8-percent hydrogen by weight—more than twice as much fuel per pound as earlier hydrides. These would allow for storage systems safe and light enough for cars.

Hydrogen Today: Clean Car Power

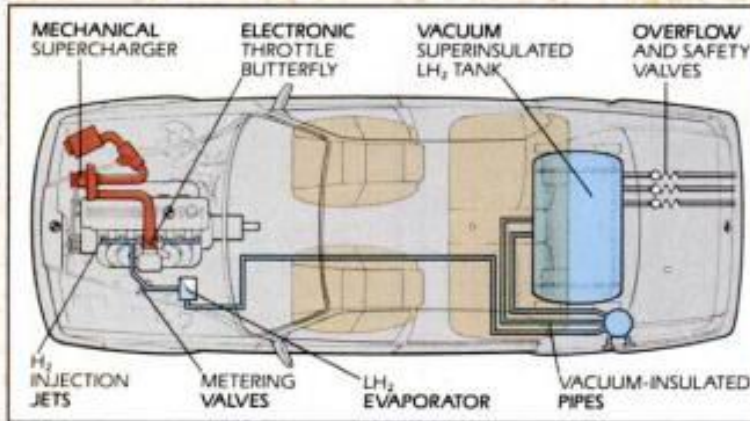
ALTHOUGH alternative fuels, such as methanol, have grabbed a lot of attention for their ability to cut emissions; nothing has been found that would eliminate automotive pollution entirely. Nothing, that is, except for hydrogen.

Several experimental vehicles are now on the road, representing a variety of approaches to hydrogen's engineering challenges. Because of acute pollution and energy security worries, the Germans have

produced the most advanced cars. BMW has focused on using liquid hydrogen stored in vacuum superinsulated tanks. (See "Hydrogen-Powered BMW," page 61, Nov. '89.) Although complex and expensive, a liquid hydrogen system is the best current compromise between weight and range. Mercedes has used metallic hydride storage media, which are completely safe, but need to be very heavy to store large amounts of fuel.

Although not as technologically sophisti-

cated as the German programs, a car conversion project recently begun at Riverside Community College in California is the most significant U.S. effort, because it has the support of the South Coast Air Quality Management District. Representing some of the most heavily polluted areas in the country, the district has taken the lead in developing antipollution technologies that are likely to be adopted elsewhere as pollution problems spread. —A.D.



BMW's hydrogen-powered car is the most advanced one currently on the road. It carries fuel in high-density, liquefied form to extend range.

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FAST FERRY

A new breed of cat breaks the transatlantic record, and enters service as a 50-mph car-and-passenger ferry.

BY ABE DANE, Science/Technology Editor



● Shortly after dawn on the peaceful waters of Massachusetts' Taunton River, seafarers looked up from their labors to behold a bizarre sight. Gliding past still-sleeping villages on a pair of razor-thin pontoons, a towering white vessel made its way quietly inland. Jutting down from its underside was a sharp, hollow-ground wedge that skimmed a few feet above the water, a keenly honed cutting implement intended to slice through rough seas at high speeds.

Phones were soon ringing at local newspapers and TV stations as baffled mariners sought to learn what brought this peculiar conglomeration of sharp edges and acute angles to these normally predictable waters.

It turned out that what they had glimpsed was an unintended preview of the future of high-speed water transport. The craft, christened *Hoverspeed Great*

Britain, was scheduled to make its formal debut a few days later in New York Harbor. Afraid that leaks would undercut the fanfare they had planned, the owners stayed mum.

But **POPULAR MECHANICS** had been following the progress of the vessel since its beginnings at the International Catamarans shipyard in the distant town of Hobart, Tasmania. Commissioned by Hoverspeed of England, the all-aluminum 243-ft. craft had been built to bolster the company's hovercraft fleet in anticipation of competition from the coming tunnel under the English Channel, scheduled for completion in 1993. Able to continue high-speed running through seas that would shut down hovercraft operations, the wave-piercing catamaran, it was hoped, could save the trans-channel car-and-passenger ferry industry.

FAST FERRY



But the toughest test of the *Great Britain's* speed and seakeeping would come a few days later, when it set out to challenge a 38-year-old record for the fastest crossing of the Atlantic by a passenger vessel (see "To The Victor Goes The Hales," below). To get to know the craft, I accompanied the crew on an overnight voyage from New York to Gladding-Hearn Shipbuilding in Somerset, Massachusetts, where it underwent last-minute fitting out before embarking for England.

On the bridge

Arrayed below a curved windscreen running nearly the full 86-ft. width of the vessel, computerized nav instruments give the darkened bridge the appearance of a quiet video arcade.

John Lloyd, the ship's master, is testing controls that direct thrust from two massive, Italian-built waterjets mounted at the rear of each pontoon. Each maneuvering jet is paired with a nonsteerable boost jet that cuts in for high-speed running.

Lloyd twiddles two joysticks used to control the jets' steering and reversing buckets in low-speed maneuvers. Ceiling-mounted dials indicate the response to his inputs. At first, one of the jets won't steer, but within a few minutes the problem is traced to a circuit breaker and set right. Word comes from the engine room that the maneuvering engines are ready, and we cast off.

Backing the vessel gingerly out of its downtown Manhattan slip, Robert

Clifford, managing director of International Catamarans, stands in the starboard bridge wing, working a duplicate set of joysticks. Clear of the wharf, the flip of a switch cuts in a computer that coordinates the movements of the steering buckets with those of a small, stainless-steel steering wheel at the center of the bridge. "This is wild," exults the harbor pilot.

As we pass the Statue of Liberty, two of the four engines ticking over lazily are enough to push the slender hulls through the water at 10 knots. Clifford, watching the engine rooms on a video monitor, orders the engineers below to start the boost engines.

Gathering speed, we head toward the Verrazano Narrows Bridge, its lights casting a glowing white curtain

SEA CONTAINERS PHOTO

To The Victor Goes The Hales

● By averaging 36.966 knots over 3000 miles, the *Hoverspeed Great Britain* shaved 2 hours and 45 minutes off a transatlantic record that had stood since 1952. She also sparked some controversy by claiming the coveted Hales Trophy, a 4-ft., gilt silver bit of hardware held for 38 years by the now-retired SS *United States*.

Considered by many to represent the pinnacle of a golden era in ship design, the 990-ft., 240,000-horsepower *United States* bested such seagoing greyhounds as the *Queen Mary* and the *Normandie*. According to Frank Braynard, curator of the U.S. Merchant Marine Academy Museum, where the Hales Trophy now rests, a relatively light craft such as the *Great Britain* is not a fitting successor to the great ocean liners of the past.

But the trustees of the trophy saw it differently, and in July of this year, ordered that the cup be sent back to Britain.

—A.D.



Record runs of the magnificent *United States* (top left) and challenger *Great Britain* are compared (above). At stake was the Hales Trophy (top right).

PHOTO ILLUSTRATION BY PAUL RUGGERO; BETTMANN ARCHIVES PHOTO

Inside The SeaCat



PM ILLUSTRATION BY JEFF MANGIAT

Great Britain holds 80 vehicles on its car deck, and 450 passengers in airline-style seats above.

across the dark waterway. All four engines are now at 600 rpm, well short of their 774-rpm maximum. At 22 knots, the vessel seems to move as effortlessly as it had at 10—one advantage of burying the noise of the engines far below in the pontoons.

The mouth of the harbor approaches, and swells increase to 6 ft. With our speed creeping up past 39 knots, white shavings of spray curl back from the tips of the pontoons as they spear through the waves. On the bridge, the wave motions can be felt now. But there is no pitching or rolling to speak of, just small, well-damped movements that feel like turbulence in an airplane. Stephen Quigley, project manager for IN-CAT, the Australian company that designed the *Great Britain*, explained that one of the main strengths of wave-piercing vessels is that it doesn't get much worse than this. Even in far rougher waters, the ship will continue to bore through, rather than ride over the waves.

Into the pontoons

With the ship on course for Somerset, things settle down on the bridge, and William Perkins, head engineer, offers to take me below to see the powerplants. On the way down, we pass through the main passenger space. Empty of seats that will eventually hold 450, it looks like a vast, carpeted ballroom. Off-duty crewmen bed down in sleeping bags in the corners, since the short-haul ferry lacks sleeping quarters.

Access to each engine room is through a companionway atop the rear of each pontoon. Perkins opens a hatch and a truly painful blast of noise strikes my ears before he can hand me a set of ear protectors.

Below, staggered one behind the



PM PHOTOS BY BILL ASHE

Great Britain, welcomed by fireboats in New York (top), has a race-car-size helm (above left), flanked on right by radar and throttles for 16-cylinder diesels (above right).

other to fit into the narrow pontoon, two shiny new 16-cylinder Ruston diesels deliver 5000 hp each to shafts driving the jet impellers directly through sealed thrust bearings. The engines' low operating speed eliminates the need for gearboxes. Sticking up between the cylinder banks are immense turbochargers, which force-feed air and a little over 5 gallons of fuel to each engine every mile at cruising speed. Although heavier than some other propulsion options, the turbodiesels are strong on reliability and fuel efficiency.

The racket reverberating within the aluminum-walled chamber is so intense that Perkins and I can communicate only by written notes. Fortunately for the engineers, an elaborate electronic engine-monitor-

ing system lets them keep an eye on every imaginable operating parameter from the bridge, rather than lingering below.

Up from the infernal depths, I step into the quiet of the deserted bar and settle back on the virgin cushions of a banquette, imagining the crowds of convivial holiday-makers that will soon inhabit this space. A total of 10 of these wave-piercing craft will make their way from Tasmania to the English Channel over the next few years. There, they will eventually replace the slightly faster, but far less seaworthy and efficient, hovercraft altogether. But before this bar serves its first drink, the *Hoverspeed Great Britain* has the Atlantic Ocean to cross. It's too bad I'm getting off at Somerset.

PM

TECH UPDATE

News Of Tomorrow's Technology Today



PM ILLUSTRATION BY JAMES IRLING

Japan's Jumbo Jet-Freighter Of The Future

TOKYO, JAPAN—Japan's principal shipbuilders have joined forces with government researchers to create a high-speed superfreighter that will leave existing cargo ships in its wake.

The Techno-Superliner is expected to be 330 ft. long, and carry more than 1000 tons of cargo at 50 knots.

Two versions are under consideration. Mitsubishi and Mitsui are examining a surface-effect variant, essentially a big hovercraft. Meanwhile, Kawasaki, IHI, NKK, Sumitomo and Hitachi are looking into a small-waterplane-area twin-hull (SWATH) design to lift the hull above 6-ft. waves.

To meet its performance

goals, the cargo ship will run on 25,000-hp gas-turbine powerplants featuring ceramics and other advanced materials. The engines, four per ship, should boast 60 percent thermal efficiency and need a third the maintenance of conventional engines.

At full throttle, the Superliner's speed will be 2½ times the average speed of conventional container vessels. That pace will allow the ship to make the Tokyo-to-Taiwan run, normally a 3-day trip, in less than 24 hours. Travel time to the U.S. would be cut to three days.

Editor: Abe Dane
Assistant Editor: Greg Pope
Contributors: Alexander Bagley,
Stephanie Denmark, Mike Fillon,
Oliver Fultz

The researchers aim to turn the project over to a shipbuilder in 1993 and have a working Superliner by 2000.

Four gas-turbine-powered waterjets propel SWATH version of Japan's Techno-Superliner to 50 knots.

Highlights This Month

- **Splash Landing**—Jet-powered seabird may be the mightiest plane yet.
- **Person To Person**—Satellites and handheld phones link any two points on Earth.
- **Electric Dreams**—NASA has an eye on the ion engine.
- **Sky Surfers**—Hypersonic planes ride their own shockwaves for better lift.
- **Space Regatta**—Solar wind carries interplanetary sailcraft to Mars.
- **Now You See Me**—Magellan Venus probe stops playing hard to get.

PM ILLUSTRATION BY ED VALIGURSKY



Shockwave Surfers

COLLEGE PARK, MD—A future hypersonic aircraft may surf on the shockwave produced by its blistering passage through the air.

On such a vehicle, called a waverider, the shockwave clings to the leading edge, confining the high-pressure

zone behind it to the plane's underside. The waverider thus enjoys a lift-to-drag ratio 10 times that projected for conventional hypersonic planes.

Under a NASA design program, Ohio State engineers have developed specs

for several waverider vehicles, including a hypersonic-engine testbed and a Mach-6 business or spy jet.

Meanwhile, University of Maryland researchers propose a Mars mission using a waverider that carries out an aerogravity assist flying upside down through Venus's atmosphere. The wave-

Waveriders include Ohio State's Stingray business jet (left and right) and unmanned hypersonic engine testbed (center).

lider's high lift-to-drag value would work in reverse, pulling the craft down into the atmosphere, so that when it slingshots off toward Mars, it gains the maximum boost from Venus's momentum.

Tilt-Prop Alternative

LONG BEACH, CA—A hybrid aircraft with tilting props mounted midwing may offer a low-cost, high-performance alternative to the V-22 Osprey tilt-rotor. The Patriot, under development at American Aircraft Corp., will dash at more than 435 knots and have an operational ceiling near 45,000 ft.

Engines lie above the rear

fuselage, not at the wingtips as on the Osprey. Their position reduces wing-loading, which adds to maneuverability and gives the aircraft a stall speed of between 30 and 60 knots. The props themselves are far simpler than the V-22's, sacrificing hover-mode maneuverability for light weight and economy. A

ducted fan in the aircraft's nose provides extra stability in vertical flight.

AAC has designed three variants: an ordnance-laden gunship, a troop-lift version and a commuter shuttle. The company revealed a nonflying prototype at last summer's Dayton Air Show.

Patriot can carry up to 48 troops or pack massive firepower, arrayed around 360°, for shock assault.



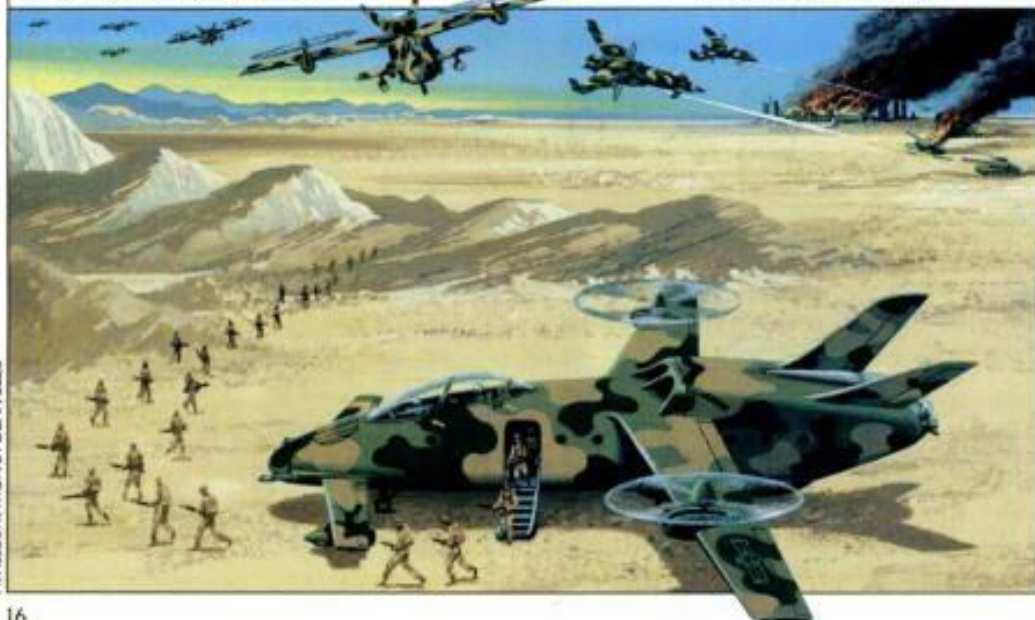
CORNELL UNIVERSITY PHOTO

X marks the spot where chip-etching X-rays emerge.

Cheap X-Rays

ITHACA, NY—Instead of dropping megabucks for particle accelerators (see [Tech Update, page 19, June '90](#)), electronics firms could make chip-etching X-rays much more cheaply, say Cornell University physicists.

They've crossed two magnesium wires between electrodes on a pulsed power generator. Pulses packing 500,000 amps vaporize the wires. Where the wires cross, radiation erupts, including X-rays suitable to write ultrafine circuits.



PM ILLUSTRATION BY DEAN ELLIS



SKYCAR

It is 1999. You can leave for work a little later than you did just a few years ago because you own a Moller 400 volantor.

BY BOB McCAFFERTY

● You enter your security code on the vehicle's external keypad. The clear canopy rises silently while an on-board computer initiates its preflight review sequence. Easing into the pilot's seat, you secure your inertial safety harness and scan the systems monitor—one of two CRT screens that replace dozens of dials in earlier aircraft. It shows all systems up and ready, then responds to your verbal command to check each item. Fuel level and pressure—check. Stability computer—check. Battery—check. Ignition—check.

Another voice command, combined with your operation of a microswitch on the throttle, starts all eight engines. Hardly a sound comes from the rotary powerplants, but the full-color monitor verifies engine temperatures established and pre-lift-off power attained. Your three self-checking, cross-checking computers confirm all systems ready. Your pulse quickens as you roll forward out of your garage.

With a nudge to the throttle, your volantor (a European term meaning to hop nimbly about) rises to 3 ft. Scanning the CRTs, you complete your hover check. All okay. An easy forward motion on the righthand joystick and you're accelerating, engines humming quietly at 65-percent power. The computer assumes control to attain the rate of climb and altitude you've preset. A quick glance at the flight monitor shows an airspeed of 160 mph and a 4800-ft.-per-minute climb. Slightly more than a minute after liftoff, you are 1 mile up and traveling five times faster than the highway traffic below. Welcome to 21st-century commuting.

A different dreamer

That scenario could be just the pipe-dream of yet another of the dozens of post-World War II inventors who

promised us our own personal commuter plane. But ex-boy genius, hummingbird admirer, aircraft welder, aerodynamics engineer, University of California professor, backyard inventor and true believer Paul Moller is different.

So say state of California future transportation planners and a top vertical-takeoff-and-landing expert at NASA. "This is extremely significant," says Dr. John Zuk, chief of NASA's Office of Civil Technology. "It's really a breakthrough for the type and concept, and it has merits from a cost standpoint that show promise to be a future personal transportation system."

What Moller has done, after an estimated \$25 million, 500,000 hours and

have enough engines that it can tolerate a failure on one during some critical mode of operation and still get back down. Finally, and probably the most important thing, it has to be fundamentally inexpensive."

A custom-designed Wankel rotary engine is one reason why Moller may succeed where others have not. It provides the power-to-weight ratio vertical takeoff demands, yet is inexpensive to produce. Moller bought technology information on a single rotor engine from the Outboard Marine Corporation (OMC)—which had used it to propel snowmobiles. Then he upgraded it into an air-cooled, 2-rotor, mostly aluminum powerplant that weighs just 72 pounds. Moller is nearing his production vehicle goal of a



Moller's first M400, shown at his Davis, California, plant, should fly this year.

25 years of single-minded effort, is to fly a 2-man, saucer-shaped, 8-engined, vertical-takeoff-and-landing craft at an altitude of 40 ft. for more than 3 minutes. "It's a true first," Zuk says.

Practical transport

Today, Moller's goal is to build a practical transportation vehicle of the air. "There are three really clear-cut criteria," says the 53-year-old inventor. "It has to be easy to fly. It has to be extremely safe—for example, it's got to

1.3-liter engine that cranks out more than 150 horsepower. That's more than 2 horsepower per pound. Durability will be enhanced with a NASA-developed plasma-sprayed ceramic coating on the engine's interior.

Next, Moller invented a system of variable-camber exit duct vanes (see illustration on page 37). These direct thrust from 7-bladed, variable-speed fans mounted on each engine to produce lift for vertical takeoff and hover. Computers reconfigure the vanes in flight to replace lift with forward

thrust. "We do with software what helicopters do with hardware," Moller says. Moller holds the worldwide patent on this combined system, as he does on six of the 70 changes he built into the engines.

Two engines are to be mounted in each of four nacelles. The synchronized, counterrotating fans face toward each other to confine prop-tip noise to the center of each nacelle. The engines themselves are muffled with another Moller invention: the Supertrapp muffler, which will keep noise down to less than 30 percent of that from a Cessna on takeoff, according to Moller.

Moller created the muffler technology years ago. It evolved into the world-renowned Supertrapp motorcycle muffler, which, as a \$4-million-a-year company, helped finance his commuter vehicle work.

The Moller 400

Moller's innovations are now being combined in the first fullscale, flying prototype for a production volantor. The nearly completed Moller 400 will carry four people, cruise at up to 322 mph (top speed 420 mph), have a climb rate of 6300 ft. per minute, a ceiling of 40,000 ft. and a range of 710 miles. With a payload of just under

1000 pounds, it would get about 14 miles per gallon on standard automobile gas.

With just 24 moving parts in all eight engines—a crankshaft and two rotors in each—the potential for engine failure is drastically reduced. If one or more engines fail during the low-level transition to forward flight, a ballistic parachute system—already proven on light aircraft—would gently lower the

M400. After reaching altitude, a single engine could keep you aloft, Moller says.

How simple is it to fly this commuter-craft of the future? According to Moller, with three computers doing virtually all the work, even a mini-



The First Volantor

● Three years ago, Paul Moller climbed aboard the saucer-shaped XM-4 and achieved his first manned flight. Only a handful of technicians, investors, friends and a photographer witnessed the event.

Fifteen months later, he was ready to give the public a glimpse. After donning his motorcycle helmet, he began flipping switches to kick each tiny but powerful engine to life. One after another—Bbbr-rup-bbrrup-hhmm. Within a matter of seconds, he lifted off. With only a crane-operated safety tether (insurance company required) connecting him to the rest of the world, he rose evenly, firmly a few feet, paused, turned slightly, then moved slowly up and over a grassy area behind his plant, reaching an altitude of 40 ft. The flight lasted just over 3 minutes. "It's



The M200X tests volantor concepts—and offers hope to frustrated commuters everywhere.

exciting, but scary," he said after landing. Especially since there were some stiff winds he had to adjust for manually. The Moller 400, he believes, will be almost insensitive to such buffeting because of its small wing surfaces.

Moller's present test-bed craft—the M200X—is the third he has built. The first, a marginally stable contraption that delighted neighborhood kids on an otherwise quiet Davis, California, street, had two huge fans, but never managed more

than 36 in. of altitude. The later XM-3 drove on a single fan with eight engines. This tester reached just 2 ft. of altitude in 1968.

But the M200X, which evolved from the XM-4, flies. Not far, nor high, nor fast—but enough to cause the hopes of commuters to soar. **PM**

mally skilled pilot shouldn't have any trouble. "I could put you on a simulator for 2 hours, maybe less, and be 100-percent confident that you'd be able to fly the craft satisfactorily," he says.

The pilot has to be familiar with only two controls. "You've got a lever on your left which selects altitude and rate of climb," Moller says. "The joystick on the right determines where you want to go. You turn it, and it points the aircraft in that direction. That's it. How do you get in trouble with that? There's no real skill involved at any point of this operation, aside from familiarization with what those levers do."

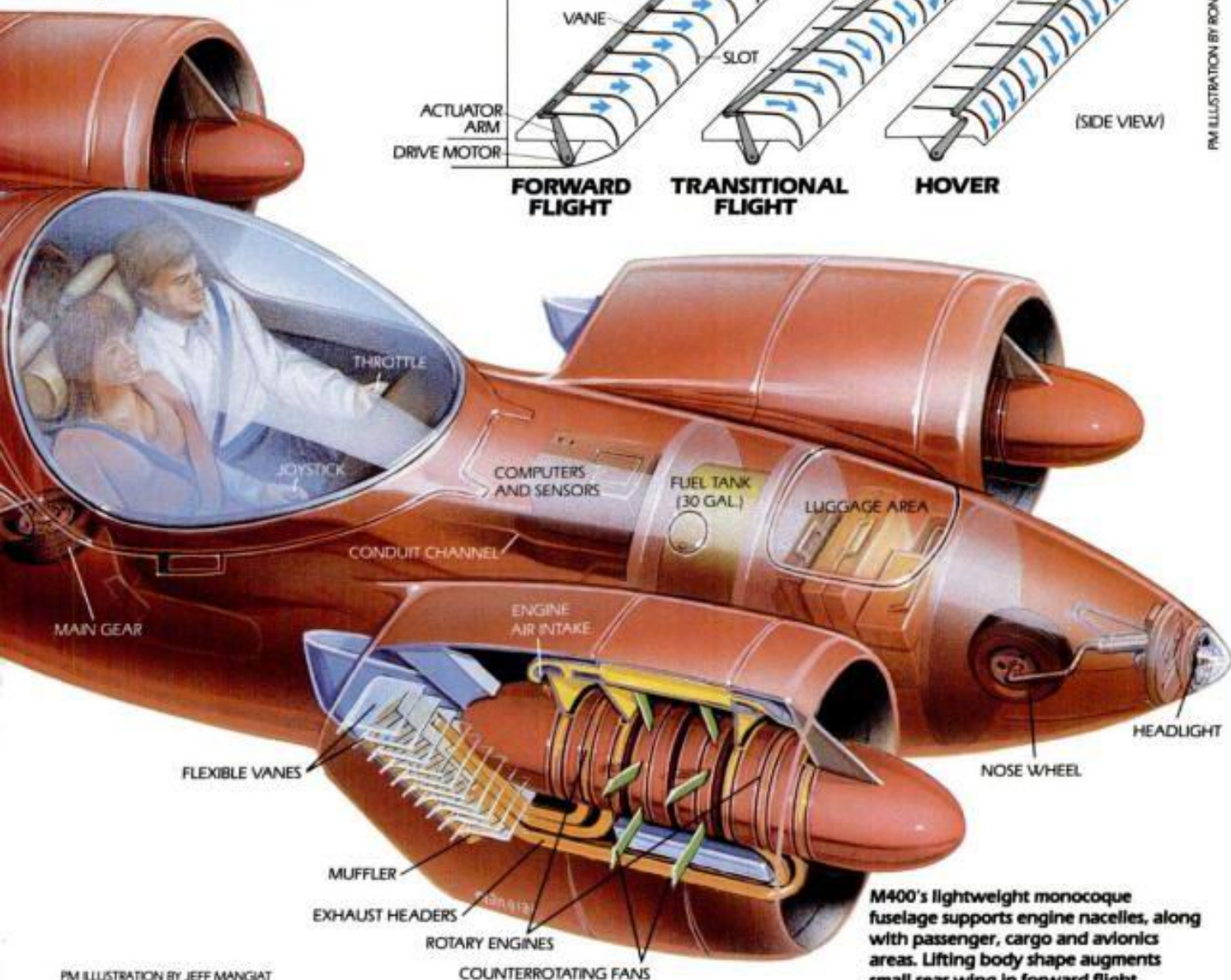
Why is Moller so confident that all of this will work? Because he has flown more than 200 manned and unmanned flights with the XM-4 and M200X since 1970, and performed 3500 hours of flight tests with both powered and unpowered vehicles in his own 200-mph wind tunnel.

Gridlock buster

When the M400 gets off the ground, it will mean more than just the realization of a dream. It may be the solution

INSIDE THE MOLLER 400

Moller's patented variable-exit guide vanes (right) slide in slots, like a rolltop desk, to change the direction of thrust.



PM ILLUSTRATION BY JEFF MANGIAT

to an impending crisis in American transportation. James Pitz, president of the American Association of State Highway and Transportation Officials and Michigan's transportation director, says, "We know traffic is probably going to double by 2010." In California, the state department of transportation's Office of Technology and Research Chief John Vostrez says, "Demand is going up something like 6 percent a year."

As the chief planner of traffic solutions for the nation's largest state, Vostrez is working on such futuristic concepts as "smart highways" with automated spacing between vehicles and on-board computers linked to a central information source. But after visiting Moller's plant, he says Moller's work "makes the technology

we're working on look fairly mundane."

Moller's unique craft also fuels the imagination of the chief of California's State Aeronautics Division, Jack Kemmerly. He is excited to see Moller combining advances in VTOL technology with fly-by-wire control. "If and when that accomplishment takes place—and in my mind I know that it will—Paul Moller will have struck gold with a technology that has real applications," Kemmerly says.

"The biggest drawback would be perhaps how we are going to utilize the airspace if we have a large number of small flying commuter vehicles. Of course, that can be handled," Kemmerly says.

Moller says all of the technical problems have been solved. Product liability

pressure—which he thinks is outrageous in this country today—and money are the only limiting factors now.

"If sufficient funds were available," he says, "we could have this thing through the transition phase and be demonstrating it three months from now." He says he could be producing several thousand a year by 1995.

At that level, each would cost about \$100,000. But if he could produce 40,000 a year, they would carry a price tag no greater than a luxury car.

So far, 65 \$5000 deposits have been made by those who share the M400 dream. They may not have long to wait. Having proven his concepts with a flying saucer, Moller says of his M400 prototype: "I'll fly it this year. I have no doubt of that."

PM

REBIRTH OF THE BLIMP

Buoyed by ultralight fabrics, new electronics and computerized design, lighter-than-air craft reclaim the skies.

BY WILLIAM GARVEY
PM Illustration by Jeff Mangiat

● After decades of stagnation, lighter-than-air (LTA) flight is booming. An amazing variety of powered, man-carrying vehicles is taking to the air. And not since the days of the fabled Zeppelins have there been flying machines as large as those now being designed for the Pentagon by Westinghouse Airships.

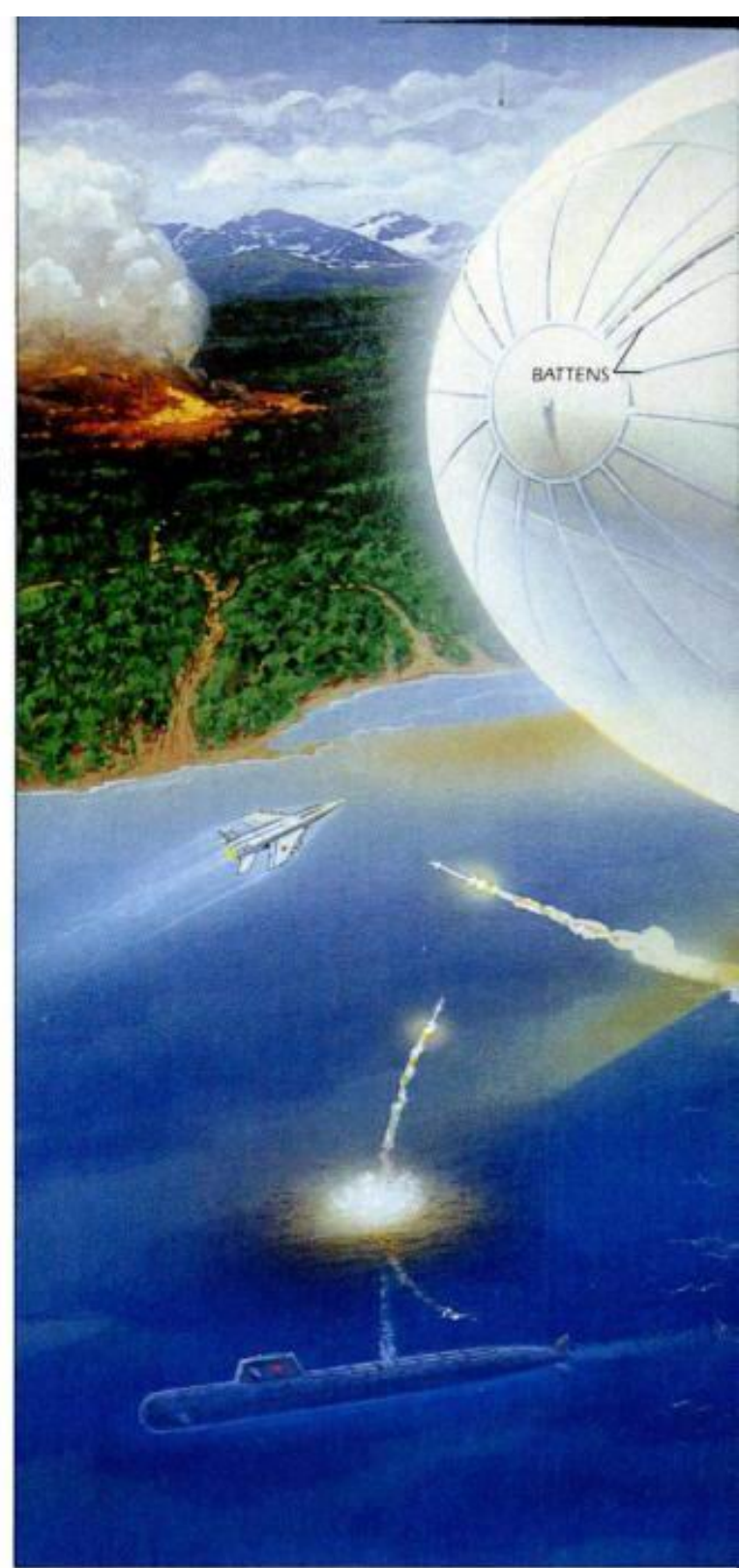
Why all this now, half a century after the end of the golden age of the airships? The days of the 800-ft.-long Graf Zeppelin, Akron and Macon. Those in the business point to the coinciding development of lightweight, high-strength materials and the miniaturization of electronics, plus the growing demand for fuel efficiency. Observed Peter Buckley, chief test pilot at Westinghouse, "The old airships were before their time. They flew around the world, yet they used pigs' intestines [to contain the gas]. All these new developments just shout lighter than air."

The result has been an unprecedented proliferation of blimps. They're hawking an airline in California, beer in the U.K., and catching bad guys in Seoul, Korea. Even the Red Chinese have built one. But the biggest news in the blimp world is taking place in an ex-Navy hangar in Elizabeth City, North Carolina.

Moby blimp

Entering this cathedral-like structure is an almost surrealistic experience. A stark, white craft floats 5 ft. off the floor bathed in floodlights and held captive in a giant net. This is the 222-ft.-long Sentinel 1000—the largest airship in the world. With its Dacron/Mylar/Tedlar envelope, fly-by-light pneumatic actuation control system, automatic venting and stabilization, sidestick controller, vectorable-thrust propellers, X-fin configuration and special instrumentation able to capture 250 different flight-test parameters, it is the most advanced blimp extant as well.

But the 1000 is just a test vehicle for an even larger follow-on craft. When the U.S. Navy takes control of the 1000 later this year, it will begin a lengthy flight regimen to explore its aerodynamics, flight controls



and ground handling, and to develop techniques for replenishing fuel and stores while underway. Meanwhile, if all goes according to plan, construction of the next-generation ship, the YEZ-2A, will begin in earnest before year's end.

This truly gargantuan craft will measure 425 ft. from nose to tail and stand 152 ft. high—that's nearly 200 ft. longer and 100 ft. taller than a 747-400. The vessel's 2½ million cu. ft. of gas will lift a 3-story, pressurized gondola (possibly designed by Burt Rutan's Scaled Composites), a crew of 12 and enough JP-5 fuel to power its twin CRM BR-2/2000 marine diesels and single GE CT7 sprint turboprop for 60 hours. But sensational as this largest-ever nonrigid airship will be to see, it's what's unseen that really matters.



Going up?

The Pentagon has already invested \$80 million and plans to spend that again and more on the project because it needs to get a radar to 10,000 ft., and the YEZ-2A is the cheapest elevator up. The blimp is to be part of the military's Air Defense Initiative, charged with identifying and eliminating airborne threats to the United States. A key element of the ADI effort is a large phased-array, electronically scanned, wide-aperture radar designed to lock on to low, small, fast-moving targets, such as cruise missiles. Planners originally intended to place the test radar, which is still under development, on a Boeing 747, but when estimates for the installation passed \$800 million—excluding the cost of the plane and the radar—they began looking for a bet-

Operational follow-on to YEZ-2A would provide flexible platform to hunt and kill low-flying missiles and planes, find submerged mines, rescue vessels in distress and detect forest fires.

ter way aloft. They hit upon the YEZ-2A.

ADI wants the big blimp to do but one job—serve as a platform for its radar tests. However, many in the Pentagon believe that once the airship is in the military inventory, the services will test it for a variety of roles, such as airborne early-warning, antisubmarine warfare, and mine sweeping and rescue. One concept even calls for a blimp armed with a variant of the Patriot missile system, turning it into a formidable anti-air-warfare platform. Westinghouse is betting that once the Pentagon flies the YEZ-2A, they'll want to order a bunch of them.

REBIRTH OF THE BLIMP



WESTINGHOUSE PHOTOS

Slow and stealthy

Although it seems ironic that the defense of the United States in the 21st century might rely on a type of flying machine that first flew in the 19th, the fact is there is simply no device with an airship's special combination of properties. It is by definition always airborne, and thus can remain on station for days or weeks. Unlike airplanes which need powerful, fuel-thirsty engines to produce lift, an airship can use small engines, reducing thermal signature and crew-numbing vibration. While perform-

ance is modest, the YEZ-2A can, with inflight replenishment, crank out a steady 60 to 80 knots, night and day, over land or sea, in fair weather or foul. Forever. It will get you where you want to go.

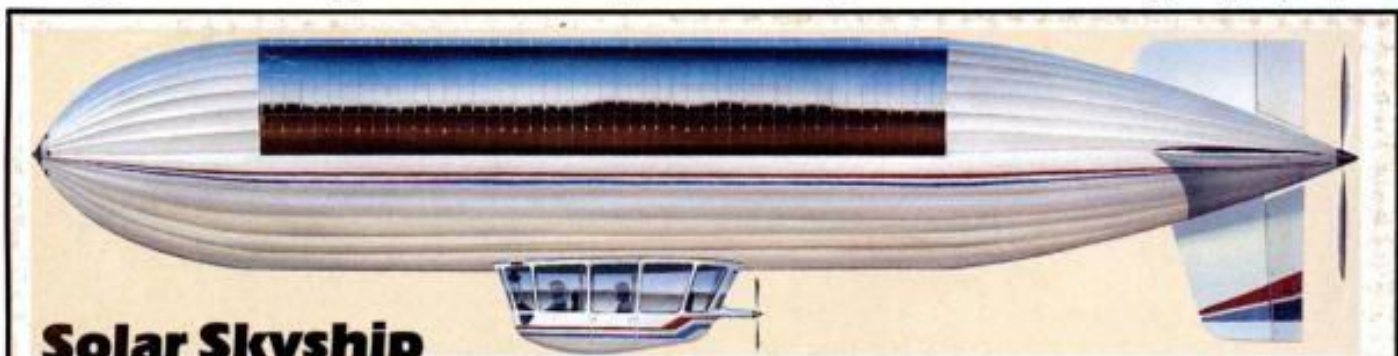
Although vast in scale, airships are surprisingly difficult to spot with an eyeball or a radar. Anyone who has tried locating a blimp from the air as I have knows that haze, low light or a cluttered or sea-gray backdrop can make the thing vanish altogether. One Navy pilot said future airships would be operated well away from

Elizabeth City hangar houses nearly complete Sentinel 1000 (above left), and mockup of YEZ-2A gondola (above).

any carrier because their virtual invisibility would make them a collision hazard to fighter and patrol pilots. Moreover, the ship's skin is literally invisible to radar, and the gondola, fins, engines and airborne radar can be configured to disperse the enemy's signal.

Giant hybrid

While it is certainly the best-known and financed big-ship project, the



PM ILLUSTRATION BY PAUL DIMARE

Solar Skyship

● While there is theoretically no limit to how long an airship can stay aloft, the need for periodic refuelings has always brought them down to Earth in the end. But now a solution—a solar-powered rigid airship—looks like it may be about to get off the ground.

Eric Raymond, former world hang-glider champion and the designer, builder and pilot of the first solar-powered plane to fly across the United States, has nearly finished plans for the craft, and hopes eventually to fly it around the world.

State-of-the-art materials and construction are the key to his design. The airship's keel and inner support structure will be made of small-diameter aluminum tubing wrapped with Kevlar thread. A thin Kevlar foam sandwich will make up the "cap," or

fitting base for the photovoltaic array that generates electricity for the engines. The rest of the airship's external skin will be of Tedlar, a Dupont product similar to Mylar, but many times stronger and more ultraviolet resistant.

Lift will come from helium contained in six separate bladders taking up most of the envelope's internal space. Batteries or, more likely, hydrogen fuel cells will be mounted along the keel to provide power for night flying.

Current plans call for the craft to be 100 ft. long, but only 18 ft. in diameter. The resulting profile is sleek enough that a 5-horsepower electric motor swinging a 16-ft. prop should be able to push it along at 60 mph. At night, on stored power, cruise speed drops to 40 mph.

The 2-passenger gondola will be built of carbon-fiber sandwich and will contain navigational, communication and emergency sur-

vival equipment. Two electric motors will also be housed there, providing thrust for landing and takeoff, as well as emergency backup power.

Despite the ship's long range, Raymond expects to make numerous stops. Some promotional, some for maintenance. Should bad weather or mishap force an unscheduled stop, the pilot can fire a rocket-propelled anchor into the ground, allowing him to come to rest without a ground crew.

For most of the trip, however, the blimp will be accompanied by support crews and weather teams. The result should be a rather grand expedition, which Raymond hopes will go a long way toward proving that current solar technology can power long-distance aircraft. —Rick Titus



YEZ-2A is not the only aerial Goliath being discussed. This spring, I spent an evening with Michael Arie, an aeronautical engineer who two years ago was named head of a new LTA division within Russia's Antonov Design Bureau. Arie's assignment was to match his nation's needs with emerging airship technology.

His biggest project is the Albatross, an airship of approximately the same weight and dimension as the YEZ-2A, but which features two Mil Mi-8 helicopter rotor systems fitted to an open superstructure slung below the envelope. The idea behind this helo/airship proposal is that with 2.3 million cu. ft. of helium keeping the whole thing airborne, all the thrust from the helicopter rotors can be used for lifting cargo—30 tons of it. (The ill-fated Helistat was borne of the same theory, but Arie says it was the outboard arrangement of four helicopters and not the concept that doomed the Piasecki machine.) That kind of muscle would be a tremendous help in resource development in the Soviet hinterlands where roads, airports and railroads are scarce.

But the Albatross is as expensive as it is complex and, well, there's not much money to go around these days. A search for a Western partner has been unsuccessful and, as a result, the Albatross has not progressed beyond some preliminary (and promising) wind-tunnel tests.

In the friendlier financial climate of the United States, New York entrepreneur and engineer Wendel Wendel is promoting an equally ambitious scheme. He says his team will have the skill and funding to launch and operate an 800-ft. rigid airship by the mid-1990s.

The purpose of the Zeppelin-size

Antonov Albatross uses helicopters and 2.3 million cu. ft. of helium to lift 30 tons of cargo.

vessels—Wendel anticipates a fleet of seven Star*Elite airships—is primarily to entertain. He plans to take well-heeled passengers on air cruises to the North Pole, up the Nile and into the Amazon. Each Star*Elite will hold 120 passengers in plush, state-room comfort.

Meanwhile, the Atlanta-based UP-ship Project wants to build a 900-ft. sightseeing ship in time for the 1996 Olympics. An adjunct to that effort



Whispership ultralight floats its single occupant skyward in near total silence.

would be a large semirigid machine dedicated to harvesting timber in the rain forests without damaging the sensitive environment there.

Little blimps that can

Airships have always inspired grand schemes, perhaps because they are technically capable of delivering on even the most outlandish of them. The trick is doing it economically. Noted Ron Hochstetler, an LTA expert based in Washington, D.C., "In the airship business you never know whether you're a visionary or a crack-

pot until it's too late." Recently, some of the most practical projects have been light and ultralight airships, two types that didn't even exist a few years ago.

American Blimp Corp. in Hillsboro, Oregon; US LTA of Eugene, Oregon; and Thunder and Colt of the United Kingdom are all producing blimps considerably smaller and less expensive to own and operate than the 200,000-plus cubic-footers pitching for Met Life, Fuji, Sea World and, of course, Goodyear (which quit the blimp building business altogether in the late 1980s).

With an overall length of 160 ft. and 138,000 cu. ft. volume, US LTA's 138S is the largest of the threesome and, with a \$3 million-plus price tag, the most expensive. American Blimp's 60,000-cu.-ft. A-60 Lightship is next in size and price at \$1.2 million. Thunder and Colt's GA42 is lofted by a diminutive 42,000-cu.-ft. envelope rigged with a 2-man gondola. Its price is similarly modest: \$650,000.

Each ship has its strong points, but of the three, only the A-60 has two engines—4-cylinder Limback L2000s rated at 80 hp each—and an internal illumination system that causes the transparent hull to glow at night. Meanwhile, all three manufacturers are now scrambling for customers, including advertisers and police forces around the world.

Perhaps the most pioneering LTA newcomers are the ultralights—aircraft so light, so safe and so simple to operate that neither the machines nor their operators need to be licensed. And with factory-new prices ranging from \$30,000 to \$50,000 for these ultralight blimps, they're the last affordable ready-built flying machines.

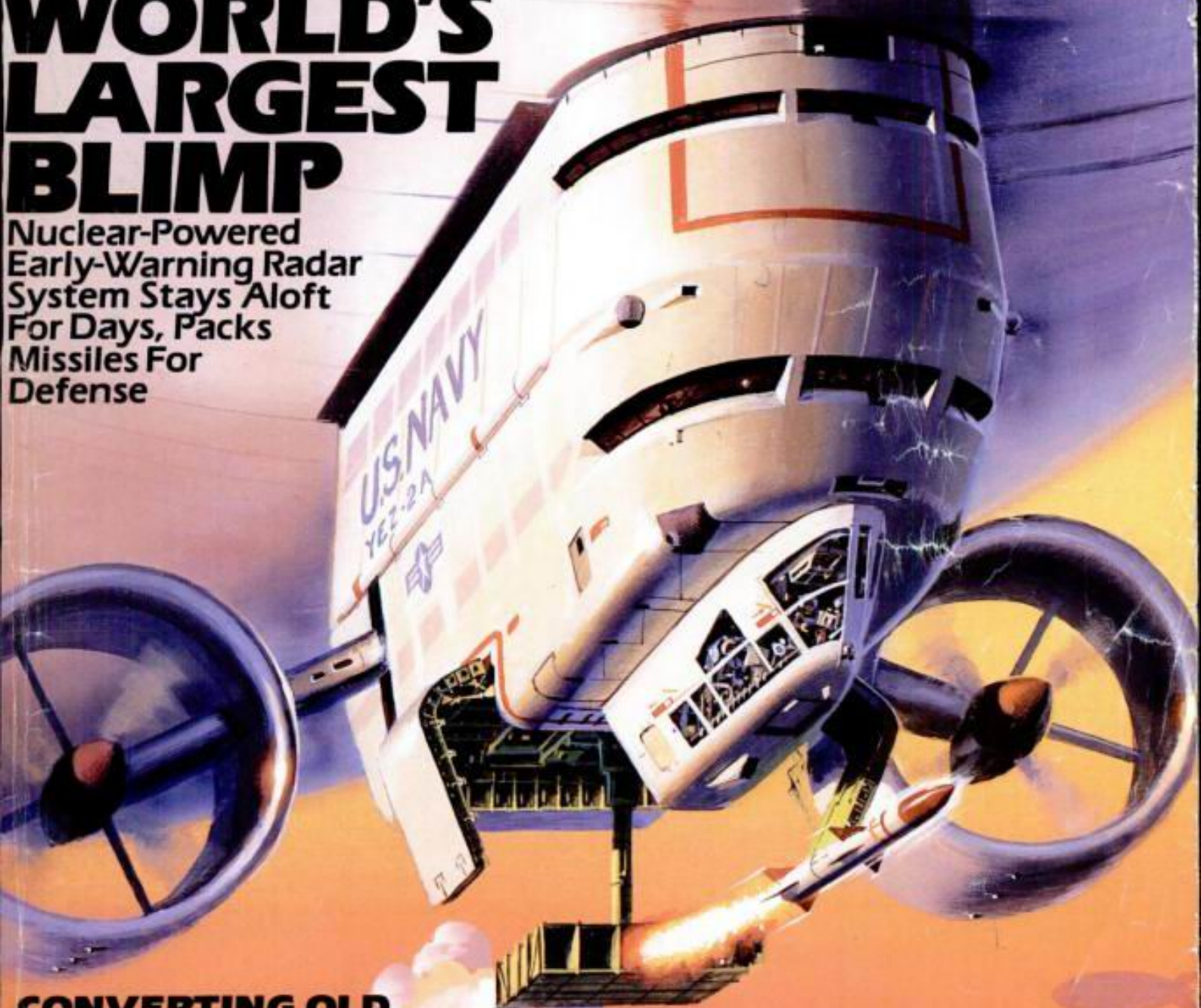
(Please turn to page 92)

AUGUST 1991 \$1.95

Popular Mechanics

NAVY BUILDS THE WORLD'S LARGEST BLIMP

Nuclear-Powered
Early-Warning Radar
System Stays Aloft
For Days, Packs
Missiles For
Defense



**CONVERTING OLD
BARNs INTO NEW
HOMES** By Bob Vila

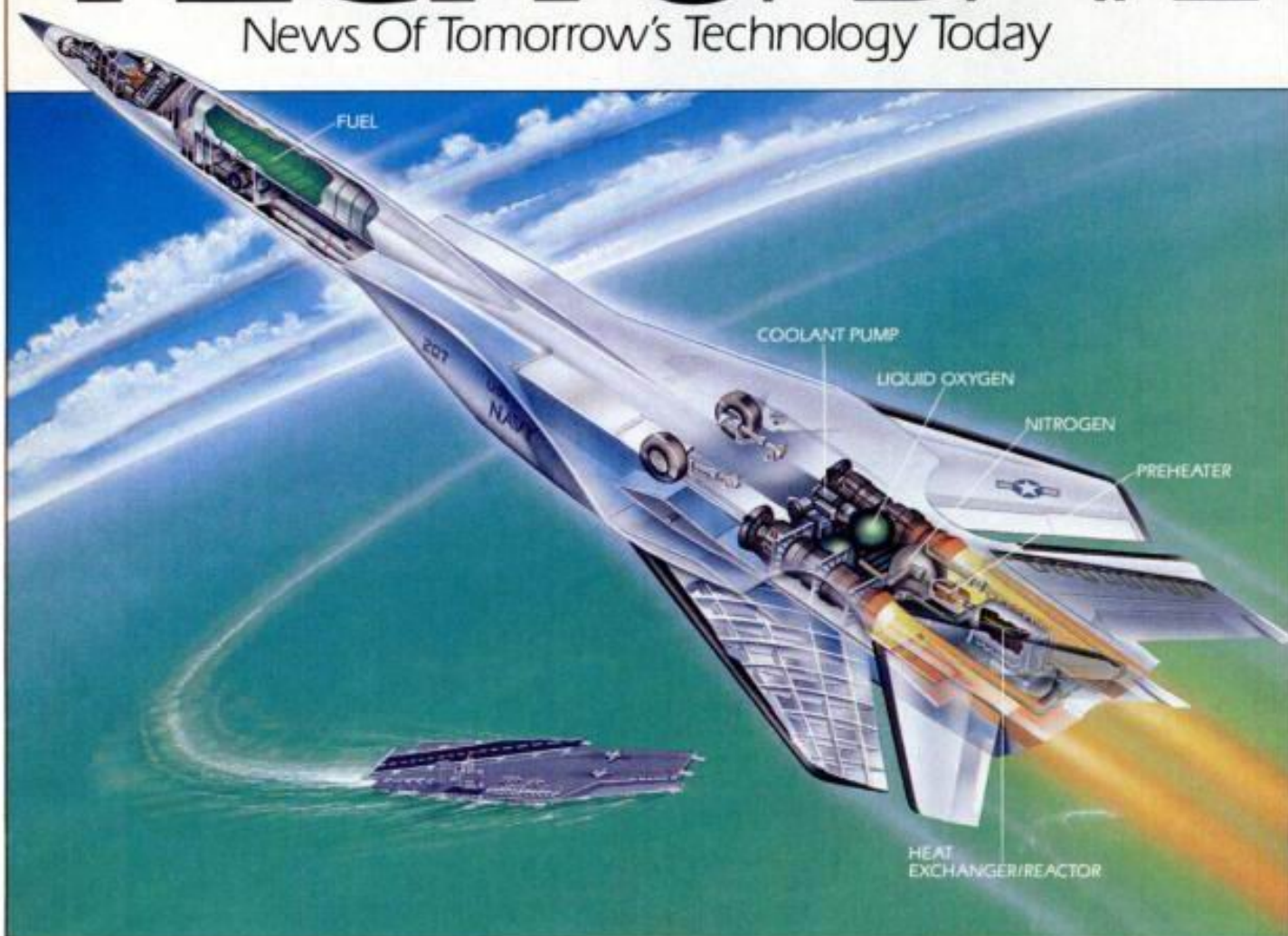
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TECH UPDATE

News Of Tomorrow's Technology Today



PM ILLUSTRATION BY PAUL DIMARE

Endothermic-Fueled Jet Could Break Mach 5

HAMPTON, VA—The Navy wants to fly hypersonic jets as much as anyone. But aircraft carriers have no room to store cryogenic fuels. Without these supercold liquids to chill leading edges and engines, a plane won't last long above Mach 4.

The solution: an aircraft designed by NASA's Langley Research Center that's based on a new technique using a separate coolant called Syltherm. What cools down the coolant is the fuel itself, known as methyleyclohexane (MCH).

Liquid MCH first flows through a preheater, where it's vaporized by warm Syltherm returning from the plane's hot spots. The gas

then passes into a heat exchanger/reactor. There, a catalyst sparks an endothermic reaction, which draws in heat from the Syltherm while converting MCH into hydrogen and toluene. These products head to the engines for combustion, while the now-chilled Syltherm cycles back to cool off the plane.

The cooling system calls for some tricky plumbing, including a pump fired by its own oxygen system and a compressed-nitrogen tank to buffer coolant expansion. The whole system weighs about 5 tons, or 13% of gross takeoff weight.

Editor: Abe Dane
Assistant Editor: Greg Pope
Contributors: Mike Filon, Bob Scheier

Researchers at Langley and elsewhere have tested the chemistry. Flight hardware remains the next goal.

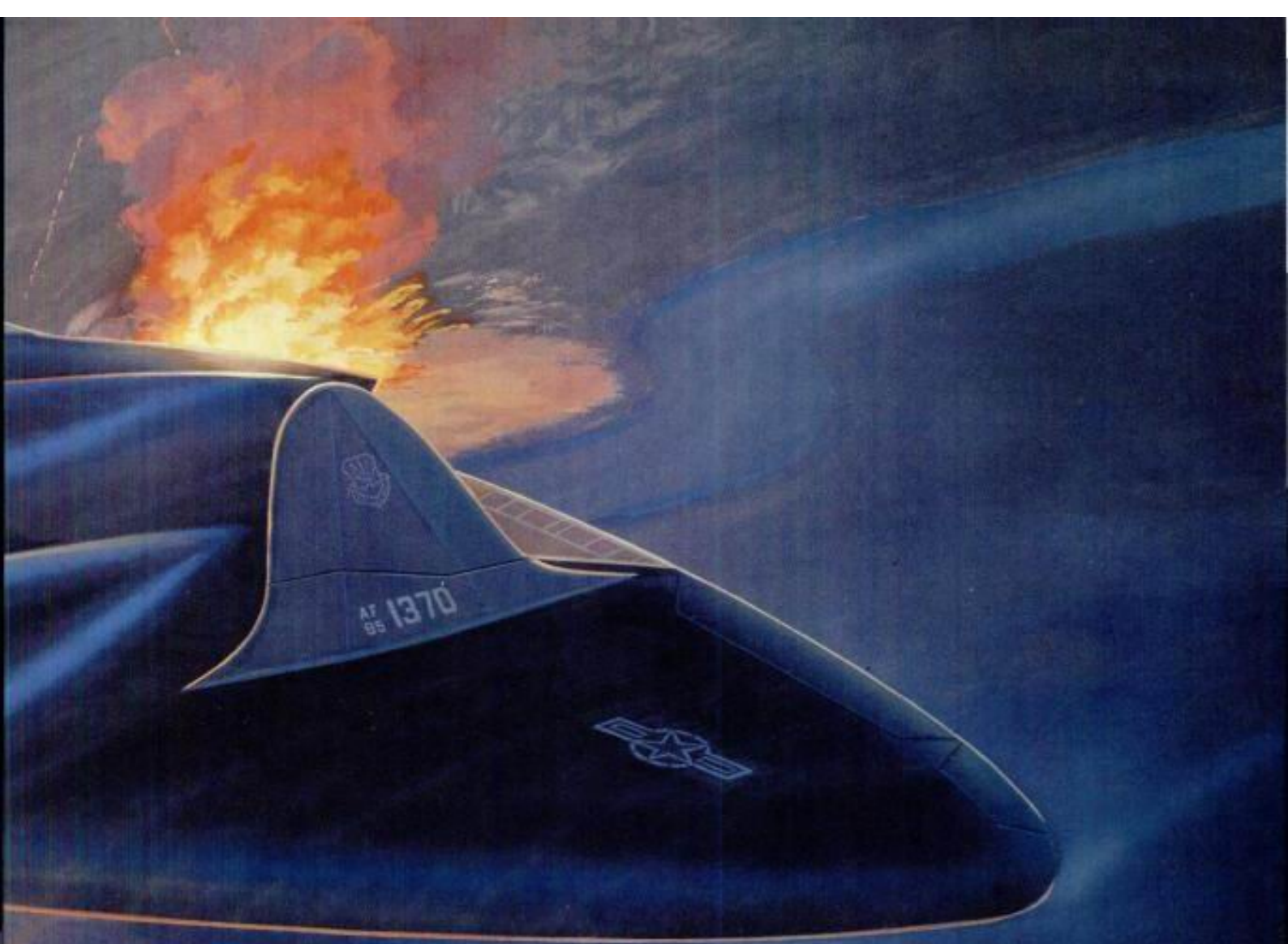
Syltherm (yellow) cools plane, then unloads heat to fuel (green). Fuel and coolant piping intertwine in reactor.

Highlights This Month

- **Easy Target**—Shoot-and-scoot tank-killer fires from soldier's shoulder.
- **Future Shock Tunnel**—Mach-24 blasts will pummel aerospace plane components.
- **Prophet Of Props**—Rutan readies his racer to snatch speed record.
- **Don't Shoot**—Infrared beacon quenches friendly fire.
- **A Swarm Of Drones**—Unmanned flyers proliferate at the Pentagon.
- **Prize Fighter**—YF-22 supercruises off with the ATF title.



Air Force's highly classified TR-3A tactical reconnaissance plane may have supported F-117A raids in Persian Gulf.



AMERICA'S NEW SECRET AIRCRAFT

Bizarre aircraft glimpsed in California's desert skies may herald a new generation of American air power.

BY GREGORY T. POPE; PM Illustrations by Mark McCandlish

● At midnight, traffic along Highway 138 has all but died. The Moon has yet to emerge, but stars shed enough light to silhouette the Joshua trees that dot the desert and the Tehachapi Mountains that rise to the north. Twenty miles to the southeast, the city lights of Lancaster throw a faint orange tint on a corner of the sky. Grasshoppers wheeze, pocket mice scuffle in the sand, a faded ranch sign creaks in the wind—otherwise, it is silent.

On nights like this, men and women have stood here and stared at the sky, looking for aircraft that officially don't exist. Some watchers spend the night and leave unrewarded. But others tell stories of lights that streak and maneuver across the heavens at impossible speeds, or triangular shapes that prowl silently overhead.

This corner of California's high desert, known as An-

telope Valley, has long served as a testing ground for ultraclassified, or "black," aircraft—from the P-59 Airacomet, America's first jet, to the F-117A Stealth fighter. Not only does the valley host Edwards Air Force Base, Air Force Plant #42 and associated contractor facilities, but test-flight paths from nearby China Lake Naval Weapon Center and the Air Force's Nellis Air Range in Nevada bring aircraft through restricted airspace into Antelope Valley.

But secrets stay closely held here. Those who know won't break their security vows. Those who think they've glimpsed the truth in the dark skies spoke anonymously to *POPULAR MECHANICS*, fearing reprisal in an area where the aerospace industry dominates employment. In the words of one local journalist, chasing secret activity "is like trying to catch smoke in a bottle."

AMERICA'S NEW SECRET AIRCRAFT

It's no secret, however, that in the past decade the Department of Defense has poured money into "black" programs. The Air Force alone has spent nearly \$46 billion on classified weapons procurement over the past five years, and another \$20.3 billion in classified research and development, according to an analysis by the Defense Budget Project, a nonprofit organization in Washington, D.C.

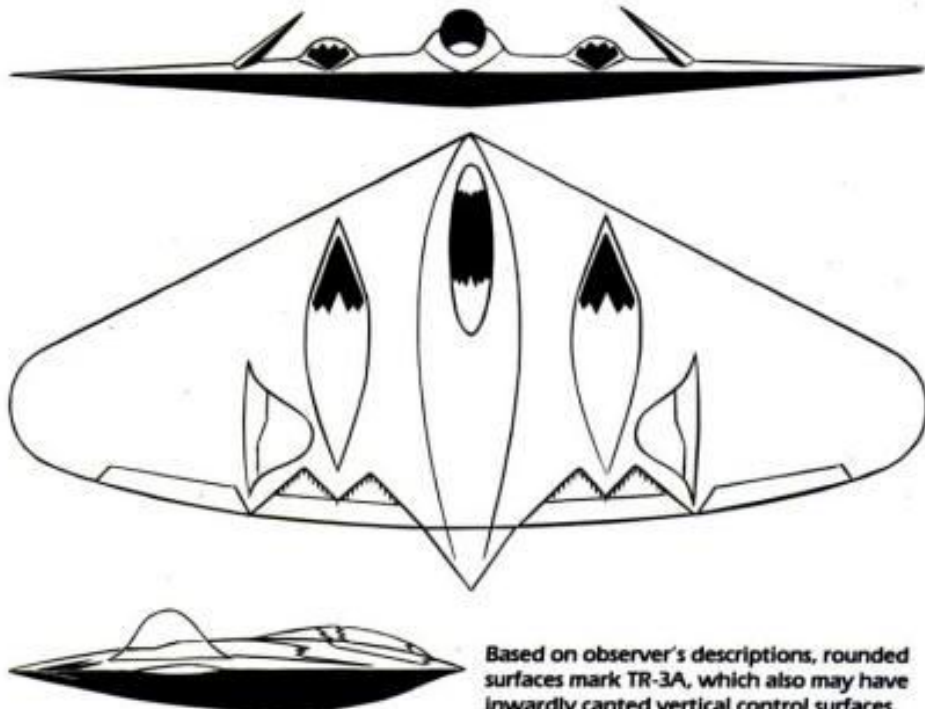
But tracing the flow of classified funds from the Pentagon to contractors reveals little about hardware. Eyewitness reports, even from unqualified observers, tell more. And a nagging consistency ties together accounts from individual eyewitnesses and lends credibility to their claims.

The vehicles in such anecdotes fall into three categories. First, observers have reported several different triangular aircraft with wingspans ranging from roughly 60 to 160 ft. Second, witnesses have described a high-speed, high-altitude vehicle, seen only as a yellow or orange light with a related pulsing engine roar. Finally, a black, silent, boomerang-shaped vehicle that stretches between 600 and 800 ft. across and performs circus-pony maneuvers at airspeeds as low as 20 knots. Asked to comment, Air Force Systems Command referred the inquiry to a Pentagon-based public affairs officer, Capt. Betsy Freeman, who issued this statement: "We have no aircraft matching these descriptions."

Black wings

Reports of the triangular planes come from the best-qualified eyewitnesses. Indeed, the journal *Aviation Week & Space Technology* asserts that one of these aircraft is the Northrop TR-3A, a classified tactical reconnaissance vehicle.

This plane, about 42 ft. long and 60 to 65 ft. in wingspan, appears to fly



Based on observer's descriptions, rounded surfaces mark TR-3A, which also may have inwardly canted vertical control surfaces.

with the F-117As that pass one by one over Antelope Valley. Its engines reportedly run more quietly than the muffled General Electric F-404 powerplants on the Stealth fighter. Ground observations are inconclusive on whether any vertical control surfaces jut from the aircraft's back. Descriptions suggest the plane evolved from a top-secret Northrop prototype concocted under the Air Force's original Stealth program in the mid-1970s.

According to the *Aviation Week* report, the vehicle has a range of 3000 miles. Its mission: to collect tactical photographic reconnaissance data and relay target information directly to F-117As in near-real time. Apparently dedicated to Stealth fighter support, the TR-3A would supplant the RF-4C in carrying out low-level recon runs if it came into wider use. But if it's capable of high-altitude missions, as *Aviation Week* suggests, the plane

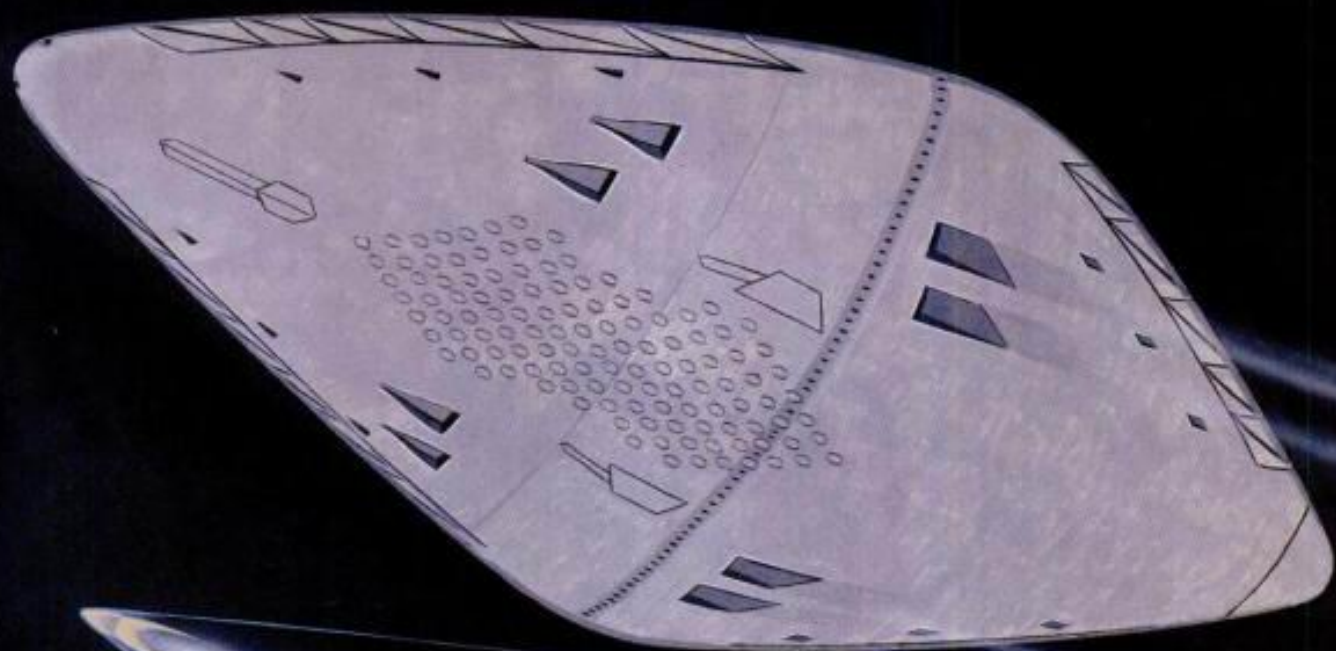
could also be a follow-on to the TR-1, a modernized version of the U-2 spyplane. Given the frequency of sightings and the association with F-117As, it's likely that the secret planes are operational and may have seen action during Operation Desert Storm.

Other reports of flying-wing triangles do not match the TR-3A descriptions. An aircraft with a wingspan close to 150 ft.—roughly that of the B-2 bomber—has been sighted by observers who insist that they can distinguish the B-2 at night. Unlike the purported TR-3A, this vehicle appears highly maneuverable. One is said to have turned 90° on its wingtip. Not spotted as often as the purported TR-3A, the craft may be a proof-of-concept vehicle for the Navy's now-canceled A-12 attack plane, an older technology demonstrator for the B-2 or a one-off experimental prototype.



Distinct from purported TR-3A, other triangular aircraft may serve as concept demonstrators. Descriptions suggest agility and possibly high-speed capacity.



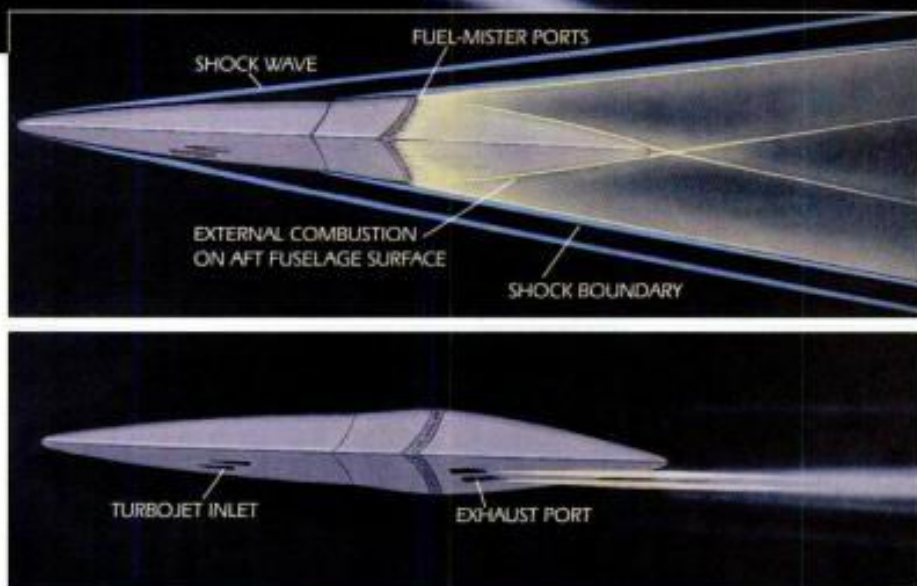


Blackbird's progeny

A separate species of air vehicle has been heard more often than seen. Several times in the past three years, a window-shaking din has awakened Antelope Valley residents between 3 and 5 am. They describe the sound as a "low-frequency buffeting," or a "pulsing roar"—"like the sky itself is tearing"—and distinct from the noise emitted by rocket engines.

Observers standing beyond the cast of streetlights tell of a swift, high-altitude light that accompanies the pulsing noise. "This object did a racetrack turn at high speed," one witness told *POPULAR MECHANICS*, "then shot straight up with tremendous acceleration." Another said the light moved from horizon to horizon—well over 100 miles—in under a minute. The descriptions correlate with reports from Nevada residents and other accounts in *Aviation Week*.

A high-flying, hypersonic vehicle has been the subject of speculation ever since a line item tagged "Aurora" appeared under a strategic-reconnaissance heading in a 1986 Pentagon procurement document. Thought to be a follow-on to the SR-71 Blackbird, analysts have placed Aurora at both Edwards Air Force Base and Nellis Air Range.



External-combustion ports (top) at mid-fuselage release fuel that burns in cone bounded by shock wave. Conventional jets (above) take over at low Mach numbers.

Whether an aircraft code-named Aurora is operational, experimental or simply a red herring, an air-breathing vehicle that flies above Mach 6 would probably rely on a novel propulsion method that might explain the pulsing sound. During the 1950s and 1960s, engineers researched external-combustion systems, whereby a hypersonic aircraft pumps fuel from its midsection into a cone of air bounded by its shock wave.

Ignited externally, combustion

gases expand against a nozzle surface shaped by the inner face of the shock wave and the aircraft's tapered aft fuselage. Such a system ensures that fuel and air stay in contact long enough to burn at high Mach numbers, says Gerald Gregorek, aeronautical engineering professor at Ohio State University. Even the scramjet, under development for the National Aerospace Plane, may function partially by external combustion.

(Please turn to page 109)

FAST FREIGHTER

Radical new hull design gives the next-generation cargo ship luxury-liner performance.



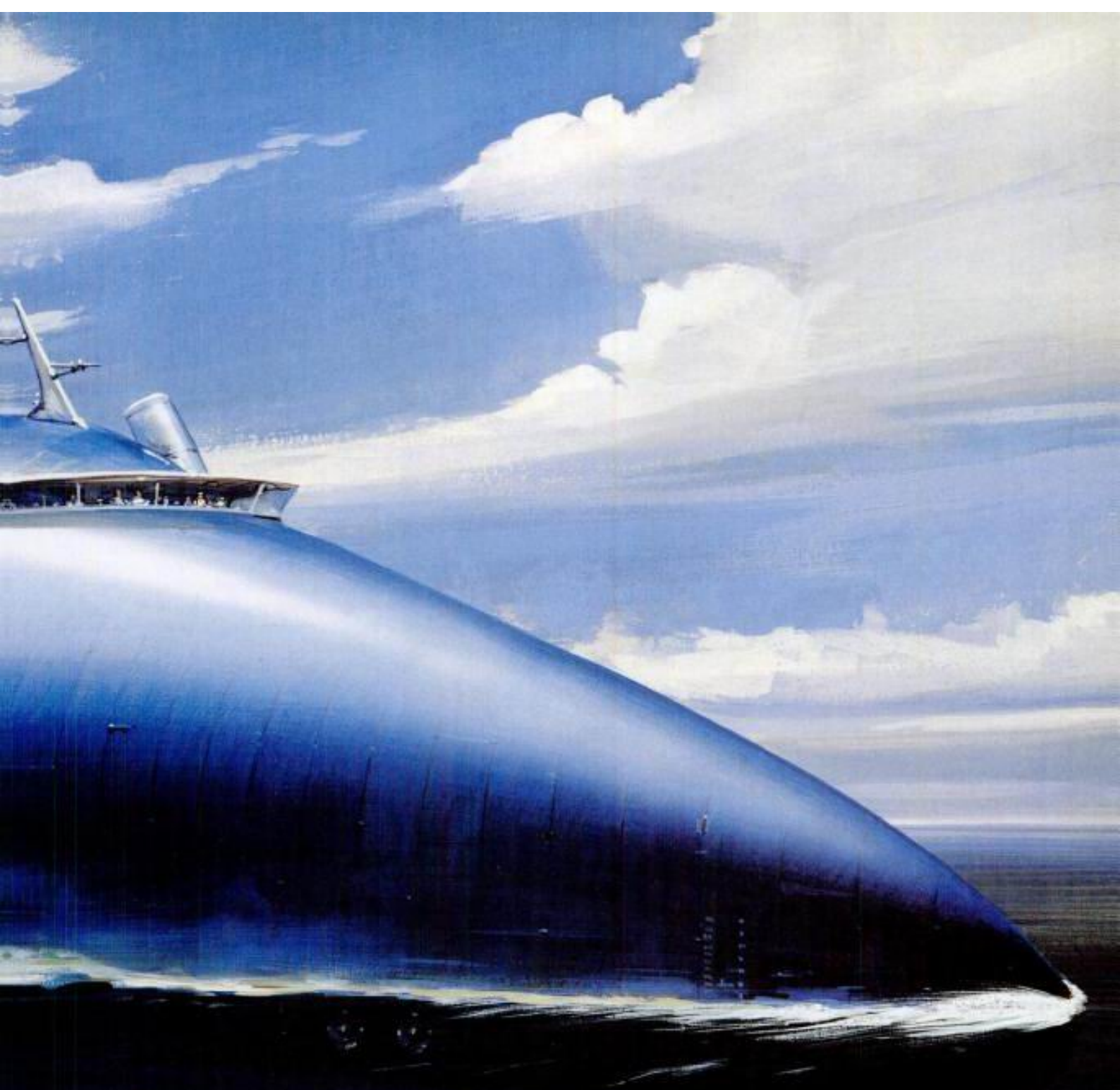
BY CLIFF GROMER, Contributing Editor; PM Illustration by John Berkey

● Forget the Love Boat. The future of shipping lies in rapid delivery of cargo, not romance under the stars. The next-generation freighter will be twice as fast as today's ships, and will look like something Darth Vader would fit right into at the helm. A concept vessel designed by the Kvaerner Masa-Yards, in Turku, Finland, the Euro Express RoRo 225 promises to revolutionize sea shipping and make it more competitive with alternative transport modes.

Present-day freighters operate at a tepid 15 to 20 knots, which is the most efficient speed range to optimize the cargo/fuel-capacity balance. More speed from these vessels is possible, but not practical. Today's cargo ships also suffer from relatively long loading and unloading times, exacerbated on occasion by the need to change the cargo-handling equipment because of a diverse load.

Starting with a clean sheet of paper, the folks in Finland went back to basics and looked at the three major ways of supporting a ship and its cargo. Displacement vessels—those riding through the water—are supported by static lift that is generated by the displaced water. Boats such as hydrofoils—a common design of fast passenger vessels—rise out of the water on dynamic lift. Air-cushion vehicles use powered static lift, and hybrid designs combine two or even all three lift forces. In all these cases, lift-system efficiency is evaluated with a drag/lift ratio—the same as is used to judge the performance of an airplane wing. Drag/lift is more appropriately called resistance/weight when applied to ships, where weight is equivalent to displacement.

Not surprisingly, displacement-hull ships show a rapid increase in resistance with increasing speed. But



they have one big advantage, which was the deciding factor for the Finns: When displacement increases above 2000 to 3000 tons, displacement-hull ships need less power than alternative designs, all of which require substantial muscle to lift such weight.

To achieve speeds in the 30-knot range, however, displacement ships require a narrow hull, which minimizes resistance. What's more, length must be at least 200 meters to prevent the ship from rising out of the water and planing. Riding on the surface, rather than plowing through the water, the ship would tend to follow the contour of the waves. In bad weather, this would make for handling—not to mention stomach—problems. So RoRo 225 designates the ship's length—a lanky 225 meters (738 ft.) long.

Having settled on the displacement category, the designers also had to consider hull options, which

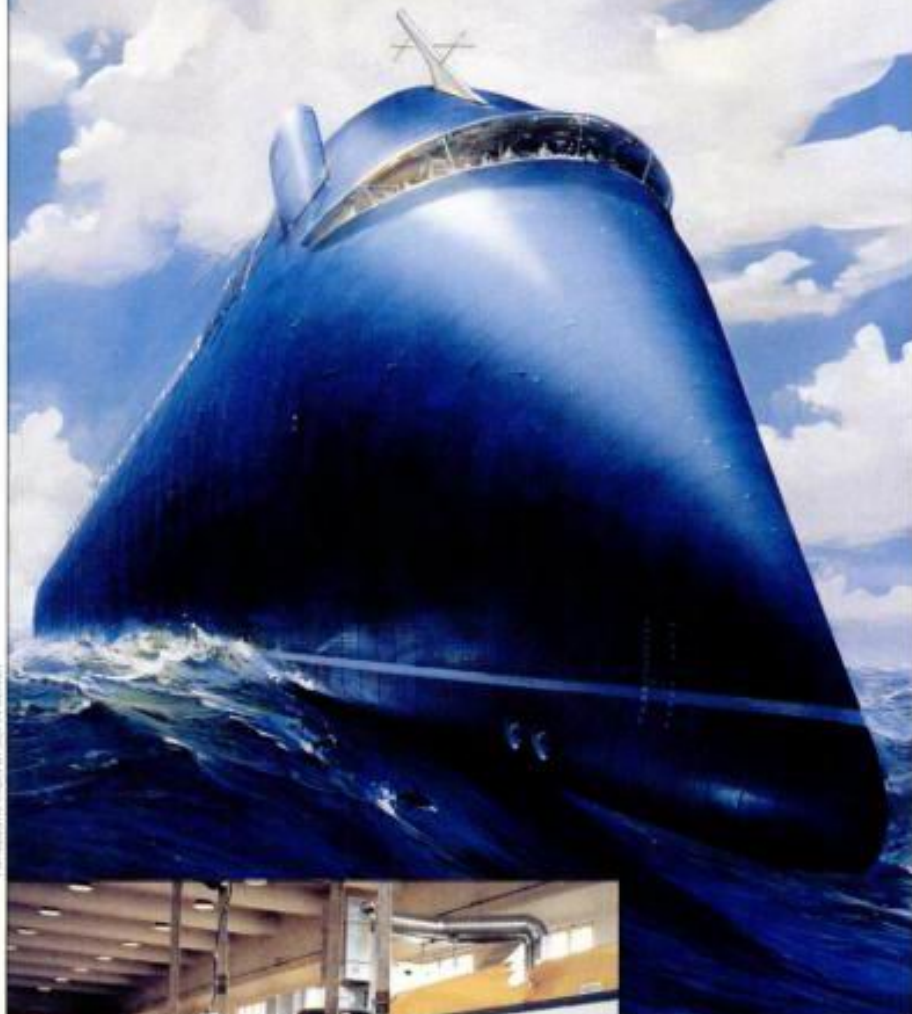
include monohull, catamaran and trimaran shapes. Model tests showed that the propulsion power for the same displacement decreased as the hull shapes became more slender, because resistance fell off. But the catamaran and trimaran designs demanded higher power levels than the monohull with the similar slenderness ratio. So the monohull design got the nod.

Frontal attack

Bow design is as critical to performance as overall hull shape. Conventional freighters use a wide, fairly flat bow, primarily to carry payload. Subjected to the heavy slamming loads generated by blasting through waves, the bow area requires heavyweight construction.

But the Euro Express saves considerable weight and cuts drag, with its wave-piercing bow design. The ship slices, rather than slams, through the waves.

FAST FREIGHTER



The tubelike hull shape is built like an aircraft's monocoque fuselage for strength and reduced drag.

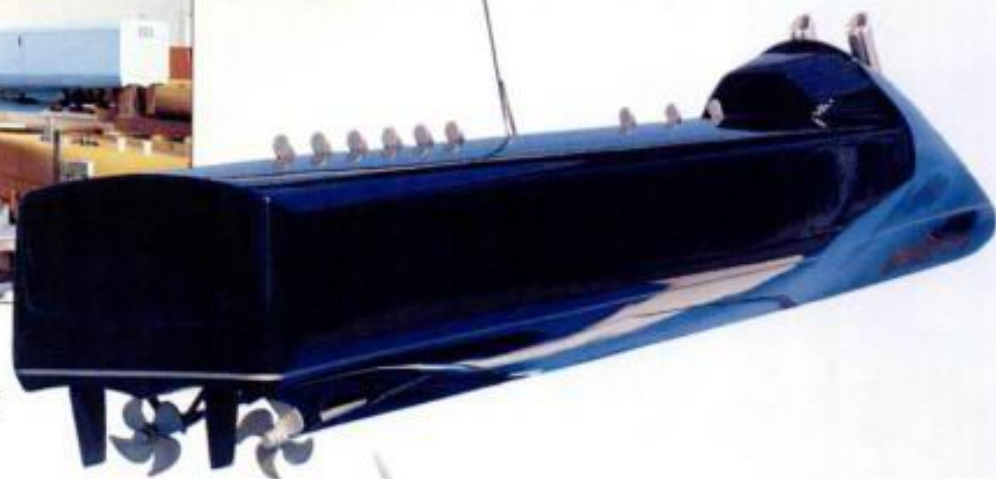
Needle-nosing the Euro's bow helps inject the ship through the waves, but there's a flip side: The bow is too narrow to carry cargo, which means less payload. Even so, the forward area is put to good use by housing the new, efficient twin General Electric gas-turbine generators, which each produce 55,000 horsepower.

Conventional ships usually locate the primary powerplant amidships, driving the propeller directly through a reduction gear in a unit power design. But the Euro Express breaks up and separates powertrain components by using a separate electric motor to drive the prop through a reduction gear. The prime power sources (the gas-turbine generators) are located in the bow, and the electric prop motor, aft. The loss in driveline efficiency, versus direct drive, is only about 5% to 6%. This is offset by having an unobstructed midship cargo area, as unit drive systems can intrude into payload space.

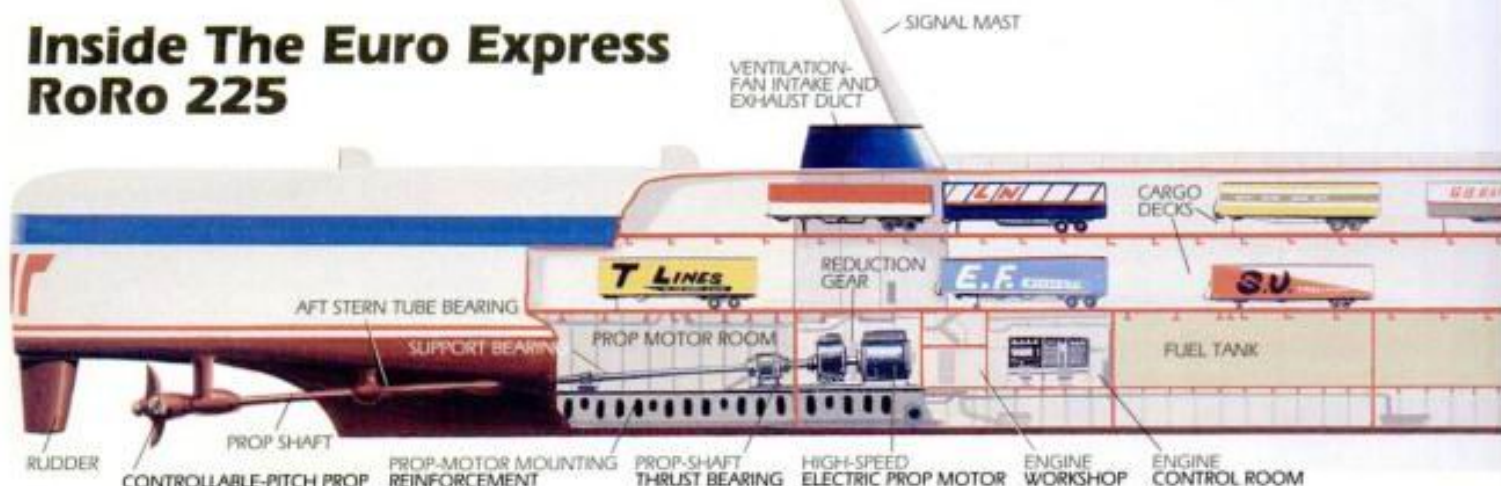
Beyond filling otherwise vacant real estate, the Euro Express power arrangement lends seakeeping ability. Conventional freighters sometimes mount the prime power source up on the weather deck, as the bow area is used for cargo. But this raises



A 1/40-scale model Euro Express underwent development in a test tank to determine power requirements and seakeeping ability, or how the ship behaved in simulated rough-sea conditions.



Inside The Euro Express RoRo 225

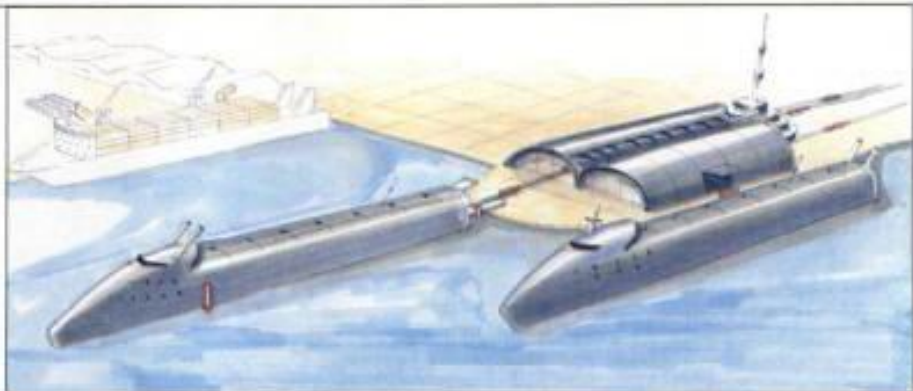


the ship's center of gravity and adversely affects stability. In contrast, the Euro Express mounts the heavy components low in the ship.

Much of the Euro's weight savings comes from building the hull from lighter-weight, ultrahigh-tensile steel that is about 50% stronger than conventional steel. While high-tensile steel requires different welding techniques, shipyards can still use the same welding equipment as they do when building ships with conventional steel. They simply adjust the speed and current output of existing welding machines, to maintain the steel's fatigue strength.

Although high-tensile steel is being used to build bridges in the U.S., it cannot now be used in American shipbuilding since there are no standards for it in place by the American Bureau of Shipping Classifications. That needn't stop overseas shipyards from using the metal, however.

The Finns saved even more weight by designing certain structures, such as crew quarters, from fiberglass. A common material in pleasure boats, fiberglass is usually unacceptable in large commercial vessels because of the toxic fumes created when it burns in confined areas. But using fiberglass on the open deck areas minimizes the fume problem. Overall, compared to the same vessel built with conven-



Simpler docking facilities are required for the Euro Express, which ties up at the rear.

tional steel, the low-fat Euro Express enjoys a 20% weight savings, which allows double the payload capacity compared to the same ship built with conventional steel.

Tales from the dockside

Efficient underway, the Euro Express offers other advantages over current cargo ships dockside. Highly maneuverable with twin props, rudders and bow thrusters, the Euro Express can dock without the need for tugboats. Both conventional freighters and the Euro Express use multilevel cargo decks, but that's where the similarity ends. The standard way a freighter takes on cargo is via crane through the upper deck into the main hold. Forklifts and other equipment then distribute the cargo to other

levels via an internal ramp system.

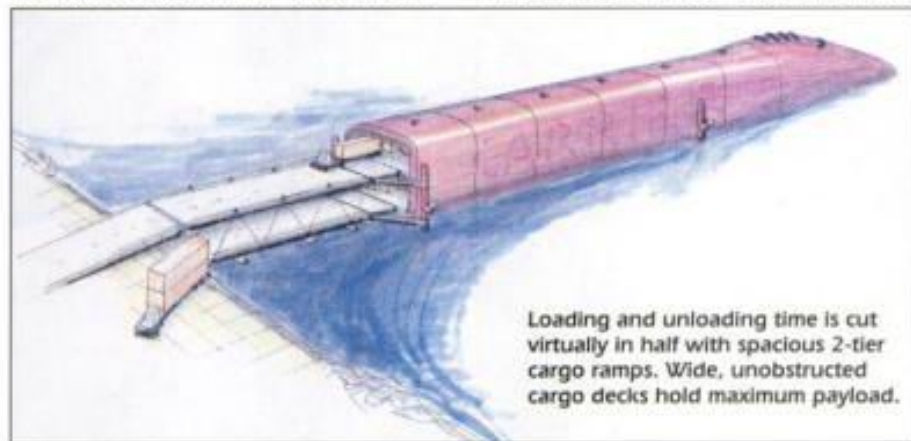
By contrast, the Euro Express loads its cargo via the rear of the ship through its upward-opening stern gate. Separate loading ramps lead from the dock to each cargo deck and eliminate the internal ramp system. RoRo has nothing to do with oars—it's short for roll-on, roll-off. Trucks or cargo transporters drive right into the ship and simultaneously load each cargo deck. Loading and unloading time is cut virtually in half.

Because of this stern-loading arrangement, port facilities for the Euro Express would require a different setup than for conventional freighters. The shore facilities would be simpler and less costly, because a side-loading dock with cranes isn't even required. The Euro Express would back into a stern tie-up, the way passenger ferries do today. A separate securing link would hold the bow fast, and the stern ramps would be secured to the cargo decks.

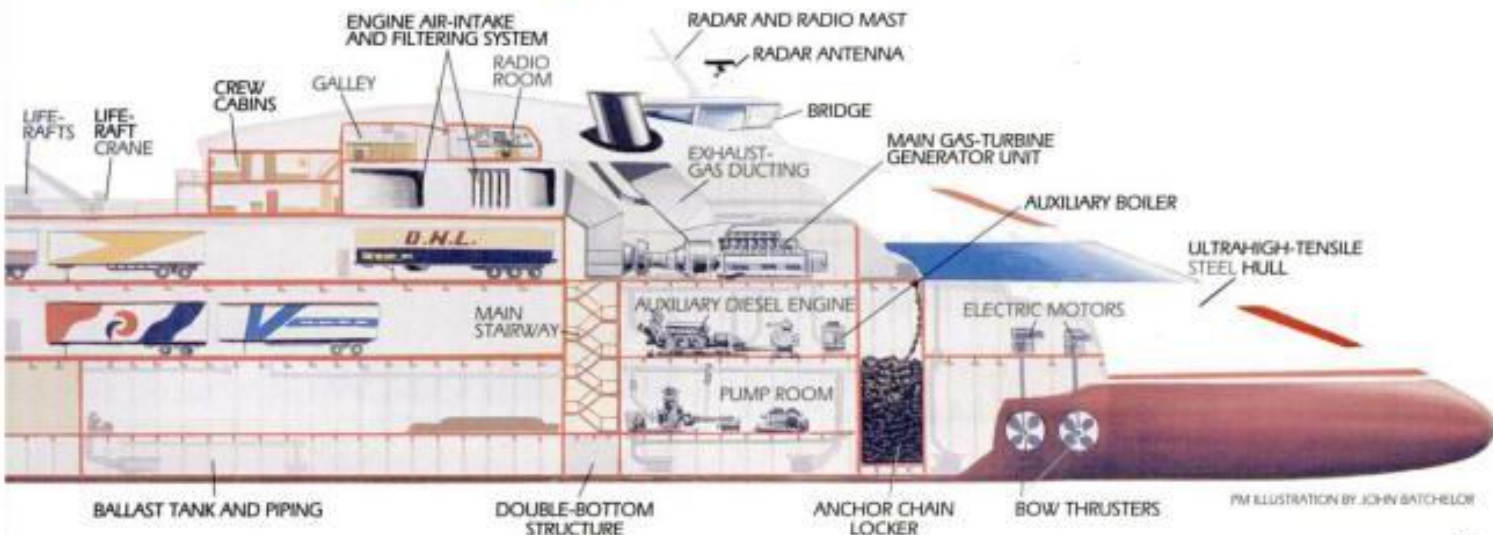
Simplified docking also lends itself to an automated mooring system, which would reduce time in port even more.

Fast freighters will most certainly be a reality by the year 2000. While more than one design no doubt will be competing for the business, the Kvaerner Masa-Yards, with their Euro Express RoRo 225, looks to be a fast finisher.

PM



Loading and unloading time is cut virtually in half with spacious 2-tier cargo ramps. Wide, unobstructed cargo decks hold maximum payload.



PM ILLUSTRATION BY JOHN BACHELOR